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ELECTRIC AIR DRILL IN GERMAN PORPHYRY QUARRY.

TYPICAL ELECTRIC-AIR DRILL EMPLOYMENTS

The half-tone on this page must be left to tell its own story, as we have little definite information at hand concerning it. We are simply given a lifelike view of an electric-air drill and its operator at work in a porphyry quarry belonging to the German government.

A drill of this type is easily movable from hole to hole or to different locations, the temporary track here shown not being generally used. The reel for the wire saves the necessity even of disconnecting it if the moves are frequent and not over great distances.

This is an entirely complete, self-contained and independent unit, requiring no connection

with anything outside itself except the wires conveying the current. It often happens, especially in the regions where quarries are located, that there is a water power available within practicable distance, and until the advent of the electric-air drill a typical installation would comprise a generator near the waterfall, wires to a power house, a motor there driving an air compressor, with a man to look after it, and then air pipes to and distributed through the quarry and hose to the individual drill. The apparatus here shown embodies or rather displaces all the installation, does the work certainly not less effectively and at, say, one-third of the power cost.

TYPICAL RAILROAD BUILDING

An unusually interesting piece of railroad work has been the construction of the Elkhorn extension of the Carolina, Clinchfield and Ohio Railroad, crossing the Sandy Ridge of the Cumberland mountains. The line is 35 miles long, mostly in Virginia, with one terminal at Elkhorn in Kentucky, and the other at Dante in Virginia due south of the former. With the exception of a little more than a mile at the Dante end, the grade over the entire line is descending toward the north.

Practically the entire line is on side hill as the location follows the streams very closely, cutting through tunnels wherever necessary to save distance. In the 35 miles there are 20 tunnels, with a total length of 3.9 miles, more than 11 per cent. of the entire length.

Although the work was very heavy the most difficult problem was the getting in of material and supplies. The country is extremely rough and in most cases there were no roads suitable for heavy hauling, and it was necessary for the contractors to spend considerable money in improving and maintaining the roads. Steam shovels, compressors and boilers were in some cases hauled from 20 to 30 miles, where little of the way was nearly level.

Most of the small tunnels were driven by putting through a top heading for the full length and then taking out a bench to the full tunnel section. Fig. 1 shows typical tunnel sections, both on solid rock and where lining was required. Caney Creek tunnel, 400 ft. long was taken out entirely by hand. The material was a soft slate with a coal seam which proved to be exceptionally good material for ratchet drills. Steam drills were used in two tunnels, and air in all the others.

As an example of the tunnel plants that were installed at points where it was very difficult to get in machinery, the air compressor used by one of the contractors in driving three tunnels about 17 miles from Dante was an Ingersoll-Rand AA2 with cylinders 20¼ in. and 13¼ in. by 18 in. The heaviest pieces handled weighed from three to 3 1/3 tons, which had to be hauled for the entire distance over the very rough mountain roads.

SANDY RIDGE TUNNEL.

The tunnel under Sandy Ridge is 7,804 ft. long and is about 900 ft. under the summit of the ridge. About 250 ft. at the north end of this tunnel was in badly broken material and requiring lining, but it is not expected that the remainder of the length will require it. The tunnel is being driven from both portals, taking out the full section as the work progresses. The headings are kept only about 12 ft. ahead of the first bench to provide room for the drills to put in a round of heading holes while the muck from the preceding charge is being removed. Four 3¾ in. air drills are used in the heading to place about 22 holes in each round. The drills are mounted on columns in the heading and on tripods on the benches, which are taken down on two levels, the upper one having 6 vertical holes in each charge, and lower bench 4. The charges are made with 60 per cent. dynamite. In each round, the lower bench is shot first and this is followed by the upper bench and then the heading. The material is of hard slate and sandstone lying in heavy ledges, some of which are as much as 10 ft. thick. All material is handled by Marion 41 shovels, operated by air and equipped with 1½ yd. buckets. Four-yard dump cars are handled in trains of five by electric locomotives.

The electric and air plants which have been installed in duplicate at the two ends of this tunnel are very completely equipped and represent a total outlay of between $60,000 and $75,000. The electric power is secured from a power house of the Clinchfield Coal Corporation on Dumps creek, about eight miles from the tunnel, where current is generated for the company's mines. This power is transmitted at 6,600 volts a.c. on a three-wire trans-

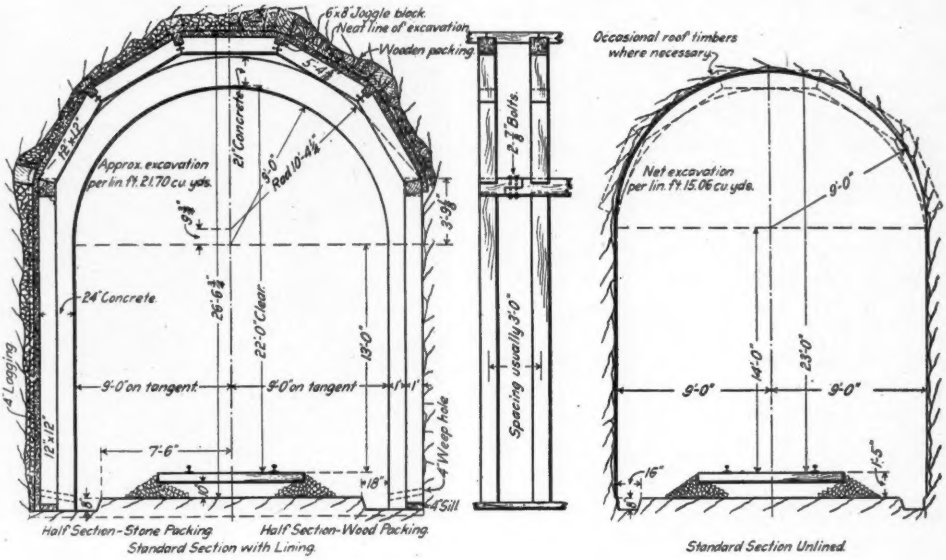

FIG. I.

mission line, and is transformed at the tunnel plants to 2,300 volts a.c. by three G.E. type H, 60-cycle, 125-k.v.a. transformers. This 2,300-volt current is used in a motor-generator set to produce 250-volt d.c. current for the lighting circuit and for operating the electric locomotives hauling the muck trains. Separate lighting and power circuits are run into the tunnel and along the approaches. Electric lights are provided in the roof of the tunnel on the center line, one foot below the roof grade, for the use of the foremen in alignment.

Compressed air for drills and shovels is furnished by Ingersoll-Rand Imperial type compressors, belt driven from 300 h.p. motors. These compressors have cylinders 25 and 15 in. diam. by 20 in. stroke. The air is carried at 110 lb. in an 8 in. line down into the approaches and tunnel headings. Ingersoll-Rand E-44 drills are used and, in addition to the eight drills in each heading, air is supplied to the shovel, two Cameron pumps, two well drills and a Leyner drill sharpener. The latter is operated by two men and is able to sharpen 200 drills in the day shift. A full stock of drills and repair parts is carried to eliminate delays. A No. 7 Cameron pump is in service at the south portal and a 14 in. fan line has been installed for ventilating at

SOUTH END OF SANDY RIDGE TUNNEL.

each end. About 100 ft. of the complete tunnel section is finished per week.

SPECTACULAR ENGINEERING.

At a point known as "the Towers" the line cuts through a tunnel 890 ft. long and in a high ridge between the sides of a loop in the river about 1½ miles long. The work from "The Towers" to the State Line tunnel is the most spectacular on the whole extension. Russell Fork at this point flows through Pine ridge in an irregular canyon known locally as "The Breaks," the mountains rising on both sides from 800 to 1,000 ft. above the river. At a number of points the walls of the canyon are nearly perpendicular. It was first planned to have two tunnels at "The Towers," the north one of the two cutting through a narrow wall of rock extending practically out to the river. As the work progressed it was found that the nature of this rock would not allow the building of a satisfactory tunnel, so that it was decided to bench off this rock wall and lay the line in open cut along the face of the bluff.

The contractor handling "The Towers" tunnel had one of the most difficult problems on the entire work in getting in equipment and material to his camp. The only access by road to this position of the mountains is by a very long, crooked trail from Elkhorn City, which winds over the mountain from two to three miles east of Russell Fork. This trail strikes a little stream known as Camp Branch about ¾ mile from Russell Fork and follows down this branch toward the larger stream, which flows into Russell Fork at a point almost opposite "The Towers" tunnel. On account of the inaccessibility of the west side of the stream from the north it was necessary for the contractor to locate his camp and compressor plant along this branch on the opposite side of the river. He hauled all material from Elkhorn over the winding mountain road for 10 miles, taking apart all the heavy machinery so as to reduce the weight of individual pieces. By using six spans of mules, and in many cases helping them with blocks and tackle, he was able to get in two boilers, the heaviest of which weighed 14 tons. He also installed an Ingersoll-Rand compressor with a capacity of 790 cu. ft. per min., and laid about 1½ miles of 4 in. pipe from the compressor to the tunnel headings. All of this pipe, the drills and all powder used on the work had to be carried

BENCHING OFF ROCK AT THE TOWERS.

on men's backs from the camp across the river and up the steep bank to the tunnel portal. In order to reach the north portal which was worked simultaneously with the south, these supplies were carried over the top of the ridge and let down by ropes along the face of the bluff.

The State Line tunnel was much easier to reach, although it also presented many difficulties. It was driven from both portals and a side drift which was run in from the face of the canyon to allow headings to be pushed in both directions from the center. One of the contractors handling grading between "The Towers" and the state line brought in a 20-ton steam shovel over the road from Elkhorn City on the east side of Russell Fork, but owing to high water, had to wait more than six weeks before he could get an opportunity to transfer the shovel across the stream.

The preceding is an abstract of a portion only of an elaborate and excellent article in *Railway Age Gazette*, Nov. 7, 1913.

The general contract for building the entire line, including clearing, masonry, grading and tunnels, was let to the Rinehart & Dennis Company, Charlottesville, Va. Hollis Rinehart, general manager of this company, has general charge of the work and E. J. Perkins is the superintendent on the ground. The Rinehart & Dennis Company is driving the Sandy Ridge tunnel and seven shorter tunnels

with a total length of about 8,000 ft., and handling about 12 miles of grading. The remainder of the work was sublet to 15 companies. The railway company will lay the track with company forces. The entire work of location and construction is handled for the company by Ward Crosby, chief engineer. The line is divided into six residencies in charge of the following resident engineers, the order being from Elkhorn south; J. W. Moore, C. D. Stanper, J. H. Charlton, C. P. Norris, L. R. Wilcox and W. C. Hatton.

JOPLIN DRILLING CONTEST

The fourth annual drill contest was held in the Joplin district, Missouri, on Sunday, Oct. 19, at which time all previous records were broken and a new record of 36⅜ ins. in Carthage limestone was established. This record was made by Smith and Long, who have led all contestants for three successive years, thus obtaining permanent possession of the gold-plated trophy hammer offered to the team making the high record for three successive years. Two other teams made records very close to that of the winner. Bailey Anderson and Q. L. Seagraves of the Commet mine at Webb City drilled 35 5/16 ins. Tom Harrison and Frank Smith of the Newton & Harrison Mining Co. of Galena, Kan., drilled 34⅞ ins. The time of drilling was 15 minutes. Moving pictures of the contest were taken, and they will be the first pictures of this great sport of the mining industry ever displayed.

LOS ANGELES AQUEDUCT CELEBRATION

In the first week of November the city of Los Angeles, California, celebrated with imposing ceremonies the inauguration of its great aqueduct. This monumental engineering work, details of which have had mention in our pages from time to time, was to Los Angeles what the Catskill aqueduct was to New York. It represents eight years of work and $24,500,000 in expenditure. It will bring pure mountain water from the snow-capped Sierras, a distance of 260 miles across deserts and through mountains. It will deliver 258,000,000 gallons of water every twenty-four hours to reservoirs nearly 1,000 feet above the city. This is enough to supply a city of 2,000,000 inhabitants, and Los Angeles is not that—yet.

LOCATING MANUFACTURING PLANTS*

BY W. L. SAUNDERS.

In considering the choice of location for a manufacturing plant the question of labor, materials, power and transportation are all of the greatest importance; and it is sometimes equally necessary to consider markets. The character of the industry should determine which of these elements is paramount.

For a paper mill or a carbide factory first consideration should be given to the question of power, because this item ranges from 50 to 80 per cent. of the total cost of the product. This is why paper mills are located where water power is available, and as wood pulp is their raw material this can usually be supplied at the least expense along a river course, where we have the power and the raw material factors controlling. Paper being made by machinery the labor cost in comparison with these other factors is not a serious item when considering location.

Furthermore, there is a certain amount of steadiness about the work of a paper mill. It is not subject to the violent fluctuations that occur in general manufacture. Such fluctuations affect the question of the volumn of labor employed, and make it important to consider the labor market of the neighborhood.

Cement factories locate where the clay and other raw materials are plentiful; in fact one seldom sees a cement works located anywhere except over a clay deposit. It is of the greatest importance, however, in the cement industry to obtain cheap power, because cement is now made by machinery, and this is one of the reasons for the cement industry in New Jersey and Pennsylvania, where coal is cheap and plants have flourished and increased to so large an extent.

In textile manufacturing, and in the machinery line, labor and transportation are controlling factors. The relative importance, however, of the labor to other items which go into the cost sheet varies with each class of manufacture. There is also the broad problem of business policy to be considered, but in a general way in textile and mehanical things labor controls the situation.

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*Abstract of a portion of an address delivered before the Graduate School of Business Administration, Harvard University, Sept. 26, 1913.

The class of labor is a sub-division of great importance. It is a fatal mistake to locate a factory where skilled labor is employed, such, for instance, as for the making of typewriters, in a locality noted only for its large supply of common labor. New England is a choice field for typewriter factories, and is preferable to Birmingham, Alabama, although in the latter place labor is more plentiful.

In textile work it has been shown by statistics that the cheap, common labor of the South does not compare favorably in cost of output with the more expensive skilled labor of New England. If this were not so we might reasonably expect that all cotton factories would be located in the South, where the raw material grows.

There are few things manufactured in America concerning which it may invariably be said that cheap labor means low cost. The contrary is usually true; for where skilled labor is employed the unit cost of product is less than in places where cheap unskilled labor is used to do the same kind of work. This in itself is a very broad subject and I shall not discuss it in detail, except to call your attention to the fact that in that part of the world where labor is cheapest; namely China, Japan and India, manufacturing does not prosper. The Japanese, with all their enterprise and skill, have been unable to compete with England, Germany or America in the manufacture of steel products, although the actual cost of labor in the steel works of Japan is one-eighth of that in the United States.

In considering the item of transportation, it naturally follows that waterways adjacent to the works afford economical transportation advantages. The importance of this item is increased as the weight of the product increases. That is, the heavier the material manufactured the more important becomes the consideration of cheap transportation. Pig iron can be delivered cheaper by water than by any other means, yet pig iron is not usually made at or near rivers and harbors, because consideration must be given to the raw material, and to the markets for the distribution of the product. If the consumption of pig iron is mainly or wholly in the interior, it might pay to locate the furnace somewhere near the area of consumption, provided raw material is available, and even where this is not at hand it may pay to transport the raw material by freight, paying for a long haul, so long as the point of delivery of the pig is in the neighborhood.

An illustration of the controlling influence of transportation may be given in marble, granite and other stone works, where the material is heavy. It may cost more to freight a block of stone than to quarry it, and where quarries are located near tide-water it is a great advantage to the business from an economical standpoint.

In the case of the stone industry, however, and in fact in any industry producing a heavy product, a tide-water advantage in location of the factory may be entirely counteracted, unless there is a market for the product close to tide-water. The great marble quarries of Carrara are situated so near tide-water that this material is loaded upon ships and transferred to the markets of the world, competing in cost of delivery, in the United States for instance, with material quarried inland, which must be transported by rail. The wealth of England has been largely built up through her coal mines, which are located so close to tide-water that this product has been, and still is, shipped to all parts of the world in competition with home industries that are not so favorably situated. It has been said that the reason why America does not supply the world with coal is because her mines are so far from the seaboard.

LOCATING IN CITY OR COUNTRY?

Having once determined the general geographical location for an industrial plant, the question then arises as to whether it is better to establish the business in or near large centers of population or remote from such centers in a rural district. On this point experts differ very materially, and before giving the pros and cons it is best to eliminate certain industries which belong to a class all by themselves; an industry, for instance, which employs so high a grade of labor that the workers may be called artists in their line; such, for instance, as engravers, silverware workers, and many other special lines which require a limited labor force, a force that is pretty steadily employed in artistic work.

In this line the country seems best suited because the trained workmen are likely to establish themselves with homes and to be free from the tempting environments of a large

city. They will be less apt to strike because of home influence, and for the further reason that there are not likely to be other sources of artistic employment in the vicinity. Strikes usually occur in the larger centers of population, and the strikers seek employment either in the same line of business or in other lines in the neighborhood, thus making it unnecessary for them to change their homes.

There are also some who advocate a country shop in cases where a large volume of untrained common labor is employed, the argument being that an untrained country boy makes a better workman than a lad from the city. It is true that the best common labor is found in the country. This is because the life and training of young men in the country is more conducive to work and good habits. The habit of work becomes established and the grade of character is usually higher.

This, however, hardly offsets certain disadvantages. In the first place, the volume of common laborers in an isolated place must necessarily be small. There is only a limited supply to draw from, and when this has been exhausted it becomes necessary to import workmen. This is frequently done by bringing Italians, Slavs and other foreign laborers to the plant, and here we reach a condition where the labor becomes most uncertain, because these foreigners only establish themselves for the purpose of making money, and not to live and move and have their being. An industry, therefore, which is likely to call for large supplies of common labor, and which may be more or less uncertain in its demand, is very likely to be handicapped if located in the country.

Among the errors often committed in locating works in the country is that of locating *near* a large city, without being actually on its border or in its suburbs. In the vicinity of New York, for instance, there are a large number of communites where men commute, going back and forth to the city each day. Where works are located within commuting distances from New York it is difficult to get workmen to move from the city permanently to the country, because they are city men. They like the city life, have been accustomed to it and are unhappy if transferred. Furthermore, wages in the city are usually higher than in the country. Now, in order to recruit a working force, the supply in this suburban city is drawn upon, and it is found difficult to get young men, because young men prefer to take positions in the large city, going back and forth each day. They will do this even at lower compensation. The city acts like a magnet to absorb young people who might otherwise render valuable service at the works.

A works management that does not give due consideration to the value of young men is an incompetent management. It is from the youthful energy of the beginner that most productive work is obtained, and if young men cannot be had, old men are employed at a disadvantage to the cost sheet. The importance of this can hardly be overestimated, because it is a well known fact that older men seek the country, while younger men seek the cities.

I should say, therefore, that in artistic specialties and where the works are of moderate size a country site is best, but in practically all other lines the points of advantage seem to be with cities. This does not mean location directly in a large city, but on its border, somewhere within carfare distance and directly in it, provided, of course, that the problem does not become one of cost of real estate or means of transportation of materials and product.

Few, if any, manufacturing lines are absolutely stable in their output, that is, manufacturing is an uncertain business, subject to fluctuations produced by general conditions that are beyond control. Mr. Carnegie has said that the steel business is a feast or a famine, and this applies to a smaller extent perhaps to almost every line of manufacture. There are busy times and there are dull times. During busy times we want plenty of men, and are increasing our force, during dull times we are laying them off, and here is where the advantage of a city is most marked. Having a large supply of labor, whether skilled or unskilled, we are able to draw upon this supply in times of activity, and in dull times we may lay men off without compunctions of conscience, because they seek work elsewhere in the same community, and many of them come back if they are wanted when times are good. To be confronted with a declining market in a country location means that we must lay off men, some of them perhaps may have been with the works for a long time. These men may have their homes there and as they must live they migrate to some other town and are lost

permanently. The alternative is for them to remain around the place in poverty and distress.

In large centers of population there are usually other lines of manufacture where the boys and girls of the workmen may be employed, such, for instance, as silk mills, stocking factories, organ factories, etc. This is an important consideration in locating works. A mechanic, for instance, usually gives his boys and girls a public school education. After that they must seek employment. If they cannot get it in the neighborhood they go away from home, to some large city usually, and this is likely to result in drawing the parents away, perhaps at the very time when they are most needed, and perhaps permanently.

Such exceptions as Gary, Indiana, cannot be used as an argument against the proposition. The Steel Corporation is so big, and its works at Gary have been established on so large a scale, that they can afford to go out in the woods, establish works and build up a city. This has been done at Gary, which can hardly now be called a country town. Besides, the governing conditions there were transportation facilities on the Great Lakes. The iron ore is brought down from the Mesaba Range by water, is converted into steel and is transported by water to the large markets.

Another exception, for instance, is that of Pullman, Illinois; and here let me say that if it is the purpose of those locating works to speculate in real estate a country site is likely to be most attractive. Pullman, however, is an example of the folly of attempting to run a manufacturing plant properly and to at the same time speculate in real estate. The two do not go together, and while there may be a temporary period of activity and profit, there is very likely to be a day of reckoning, because the one most important factor which makes for permanent success in handling men is to establish among them a feeling of absolute confidence. If they feel that they are being used to promote a land enterprise, or if their homes either belong to the company or are taxed by the company, or if they are expected to purchase them through the company, a feeling is engendered which does not make for efficiency and success. The great strike at Pullman has, I think, settled this question.

Those who claim advantages for the country site use with some force the argument that in cities strikes are more liable to occur than in the country. This is, of course, true. Unions are usually stronger in cities than in the country, but unions and strikes are passing shadows. They have no permanent place anywhere and are likely to flourish in one district or another as circumstances may change the situation. It must also be taken into consideration that when a strike does occur in the country, there is little chance to replace the strikers, there is no labor market available, while in the city there are always opportunities to continue the works, even on a reduced scale during a strike period.

In these general thoughts I do not refer to "cities" as very large communities particularly, but as places where some 25,000 or more people live, where there are amusements for the workmen, where railway and other transportation facilities are available, and where land is plentiful.

PLANNING FOR GROWTH

There is no greater mistake made in locating works than to begin on a small area that is hemmed in and which does not afford opportunities for expansion. No one can tell what the future may bring forth in a manufacturing business in America. I have seen works expand against great obstacles, such as hills and rivers in the immediate neighborhood, or against expensive land or buildings which must be acquired in order to provide facilities for taking care of the product. I have known this to become so acute that it was found best to abandon the site entirely and locate where there was more room.

It is a good rule to follow, to build with care, providing only for the immediate needs of the business, but let that building be located on property which affords ample room for growth. Small buildings and plenty of land are the best beginning. There is a further economic reason for this in that wherever works are located property increases in value in the vicinity. This has a far reaching effect in many lines of manufacture, and the concern that makes this possible should have land enough for its own future needs to warrant the investment of its capital.

PLAINFIELD WATERWORKS POWER HOUSE AND GRAVEL WELL.

A HIGH-DUTY AIR-LIFT CITY WATER-WORKS PLANT

The air lift installation of the Plainfield-Union Water Company, at Plainfield, N. J., has many interesting features besides its large pumping capacity. Its location is in a valley which shows superincumbent strata of water-bearing sand and gravel of varying depths down to a limit of about 100 ft., below which is rock also yielding water, but which differs somewhat from the former in chemical characteristics and otherwise, indicating a flow from a different source.

The gravel water, which has a normal level of about 34 ft. below the surface, is the product of the immediately surrounding watershed. A series of wells were sunk in this gravel down to the rock and had been pumped for years by two vertical duplex triple-expansion condensing steam pumps of 5 and 6 million gallons per day capacity, maintaining by means of a stand pipe a pressure of about 65 lb.

As it became necessary to increase the water supply of the city plans were made to install an air-lift plant. It was desired to use the supply from the underlying rock and to so combine the two systems that the suction installation in the gravel could be used independently of the air system in the rock, or that both could be used in conjunction.

THE ROCK WELLS.

About fourteen wells were drilled to a depth of between 350 and 400 ft. distributed over an extensive area so that they were separated from each other by a distance of at least 20 yd. They were 10 in. in diameter, having a casing driven down to and a short distance into the rock, thus effectively sealing off the gravel water. These wells were considered sufficient to furnish an adequate supply for all emergencies, but it was determined to tap the gravel waters and to pump them also by air.

To install an air and discharge pipe in one of the existing suction wells in the gravel was a simple and innocent proposition until the question of submergence arose. For a lift of about 70 ft., as here required, there should be a submergence of 60 to 75 per cent., which would demand for the piping an additional depth of, say, 130 ft.

Accordingly a 10 in. well was drilled and cased to the rock about 90 ft. deep; the size of the tools was then reduced to 8 in. and the well was extended to a total depth of 200 ft. below the surface. The well as bored then stood 10 in. down to the rock and 8 in. to the bottom. A pipe a trifle smaller than the

well and plugged at its lower end, with a 20 ft. length of screen or perforated pipe of larger diameter, connected to its upper end by a reducing coupling, was let down into the well so that the coupling rested on the shoulder of the rock where the bore was reduced to 8 in., thus suspending the pipe in the rock, the screen having a pipe fitted to it which extended to the surface.

The outlet pipe which cased the well in the first place was then withdrawn entirely with the result that the gravel water would flow through the screen and down into the pipe in the rock where it is prevented from passing out by the plug in the bottom. The air pipe passing down inside the plugged pipe nearly to the bottom completed the air lift so far as the well was concerned.

TESTING THE WELLS.

A temporary plant was installed for the testing of each well as to its yield and character and experimentally to determine the best conditions of submergence, volumn and velocity, to secure the best results. For this work a small Ingersoll-Rand steam driven air compressor was installed and pipes were laid to three wells. The offers of three air-lift concerns to equip one well each in their own manner and run a competitive test were then accepted, the company demanding that they should conform to standard form in making their tests and compiling their results. The figure proposed to be obtained was the percentage of power theoretically used in raising from the well the actual number of gallons, the actual number of feet, to the amount of power consumed by the compressor, or, in other words, the percentage of water horsepower to air horsepower.

In Table I are shown the results of the tests on well 1, which was assigned to the Harris Air Pump Company of Indianapolis, and the methods used by all in keeping the results and comparing the records.

The final figure, 30.9 per cent. efficiency, was the best obtained from any of the competitors, and was considered very good, in view of the facts that the installation was of a temporary and makeshift character, and that the compressor was not especially economical in steam consumption. From this representative well we know:

First—The number of gallons the well yields at maximum efficiency.

Second—Amount of air required.

Third—Drop, which, plus the static head gives the distance required to lift the water.

From these are derived the pressures necessary to start and run, also the horsepower and efficiency. What is to be sought is the relative point between air, water and lift where the efficiency is the greatest.

Table II illustrates this and shows the result of a test taken from one well to determine that point. With the compressor running at different speeds, the water production was measured and the pressures noted, and we were able to show the rise and fall in the relative efficiencies as the speed, viz.: air production, was changed.

It is to be noted that the greatest amount of water is produced by the greatest amount of air, and also the other extreme; but still there is a point when a gallon is produced by

TABLE I. TEST WITH HARRIS SYSTEM DEEP WELL
No. 1, 300 Ft. Deep

Casing	93 ft. x 10 in.
Air pipe	158 ft. x 2 in.
Discharge	163 ft. x 6¼ in.
Static head	37 ft.
Pumping level	60 ft.
Drop	23 ft.
Elevation	5 ft.
Total lift	65 ft.
Submergence	98½ ft.
Percentage of submergence	60.2
Pressure start	55 lb
Pressure running	47½ lb.
Gallons per minute	499
Water hp.	8.19
R.p.m.	92
Receiver pressure	51
Feet per minute	197
Air hp.	27.18
Air per gal	0.394 ft.
Over-all efficiency	30.9
Shut in press	42½
Temperature of water	54 Deg.
Duration of run	2 hours.

TABLE II. RELATION BETWEEN AIR, WATER AND PRESSURE

R.p.m.	120	100	80	75	65
Free air per minute	255	213	170	160	138 cu. ft.
Gallons water per minute	380	337	312	280	205
Drop of well	21 ft.	18.5 ft.	16 ft.	16 ft.	14 ft.
Air per gallon	672 ft.	633 ft.	545 ft.	572 ft.	673 ft.
Pressure	42	43	44	44	45
Efficiency	19	20.5	23.4	22.5	18.8%

the smallest fraction of a cubic foot of air, which point corresponds with the point of greatest power efficiency, where the relation between air horsepower and water horsepower is the greatest, and, as in this plant, so in any other plant can likewise be determined an input of air which will give the most economical results.

THE NEW PLANT.

Preliminary tests having proved conclusively that there was abundant water to be had, a large addition to the power house was built and, without interferring with the working of the old plant, there were installed two Ingersoll-Rand cross-compound condensing air compressors, with Corliss steam gear, and of the latest and most refined type, OC. 3. The main receiver was connected to air mains of 4 in. and 6 in. diameter, and to these trunk lines, the wells were joined by 2-in. lines with provisions for cutting out any well or series of wells as desired.

The wells themselves were equipped by the Harris Air Pump Co. with its patented 20th Century foot piece and umbrella top discharge, and the discharge of the wells was carried by gravity to a 500,000-gal. reservoir, from which the steam pumps took their supply for distribution.

After this plant had been in operation about one year, it was decided to make a test and determine how the wells had been affected, and also what was the general working condition of the system. Under normal conditions of water production and steam consumption, 8 wells working simultaneously were giving an ample supply of water, and the compressor, governed by the pressure regulator, was making about 77 r.p.m. As it was obviously impractical to measure either the supply of air or the discharge of water from each well individually, and thereby obtain the efficient working of each well, a much simpler and more ingenious method was employed in determining the theoretical percentage of submergence for the well in question and then proceeding to adjust the air throttle at the well, at the same time noting the change of pressure which would denote the change in submergence.

When the submergence was so adjusted that it comprised with the total discharge pipe the right percentage of submergence, we may assume that the well was working at its most economical point. The result of this adjustment is shown in Table III for each well, and in each case an average was taken to indicate the general performance of the system.

WELL WITH UMBRELLA DEFLECTOR.

The length of discharge pipe in each well has been taken as 100 per cent., and, knowing the lift to be somewhat between 80 and 90 ft., we find from tables that the percentage of submergence is between 55 and 60 per cent., consequently we admit just that amount of air to the well which will draw down the water to a point that gives the shut-in pressure that determines the correct submergence.

This simple adjustment in a typical case resulted in a great saving of power, for, on returning to the power house, it was found that the compressor had automatically slowed down to 67 r.p.m., the pressure being constantly maintained by the regulator, and that the wells were delivering the same amount of water. We can accordingly say that during the time elapsed since the system was first operated

TABLE III. REPORT OF TEST MADE AT PLAINFIELD, N. J., MARCH 25th, 1912

No. of wells	3	4	5	6	8	9	10	11
Depth	350′	400′	350′	300′	304′	350′	350′	350′
Length of discharge (100%)	204	204	203	204	210	217	205	213
Starting pressure (lbs.)	66	60	60	65	65	65	65	65
Running pressure (lbs.)	59	55	55	57	56	60	54	55
Shut in pressure (lbs.)	53	51	50	54	51	54	48	50
Submergence, per cent	60	57.5	56.5	61	56	57	53.5	54
Submergence (ft.)	122	117	115	124	117	124	110	115
Lift (ft.)	82	87	88	80	93	93	95	98
Free air constant	.400	.432	.440	.387	.462	.447	.485	.489

Average submergence	118 ft.
Average percentage of submerg	57%
Average lift	89.5 ft.
Average constant	.443

the wells had changed in some respects, and in other cases the throttles were admitting more air than economy demanded. This is one instance where as much as 10 per cent. of power may have been saved.

With these wells in proper adjustment, it was desired to determine the amount of water lifted, likewise the power required to produce the air for this work. As the water was flowing into the reservoir from a number of discharge pipes this could not be accomplished there, and therefore it must be measured as it passed through the steam pumps on its way to the stand-pipe with due allowance for fluctuations in the reservoir. The power required to compress the air was determined from indicator cards taken from the steam end of the compressor.

The results of this test are shown in Table IV, together with an incidental run with the pump shut down to check the slippage of the pump, and also check the actual pumpage.

From these figures we draw our general conclusions as to the economy and efficiency of the system. 3666 gal. p.m. lifted 89.5 ft. =

$$\frac{3666 \times 89.5 \times 8.33}{33{,}000} = 82.85$$

I.hp. in steam cylinder, 211.

$$\frac{\text{w.hp.}}{\text{i.hp.}} = \frac{82.85}{211} = 39. + \text{ per cent.}$$

In this case we may safely say that losses due to mechanical friction, and adiabiatic compression have been reduced to a minimum by providing a compressor of most refined and

TABLE IV. TEST

Time, a.m.	10:05	10:20	10:35	10:50	11:05
Compressor, r.p.m.	67	67	67	67	65
Working pressure	69	69	69	69	68
Water lift reservoir	30 5/8 in.	31 5/8 in.	30 in.	33 7/8 in.	32 1/4 in.
Rate of pump encounter	7743	8201	8654	9087	9561
Steam pressure	115	109	114	114	104

Average revolution of compressor per minute	66.6
Average working pressure	68.8
Revolution of pump in one hour	1818
Size of duplex pump cylinders	20 1/2 x 24-in. stroke
Gallons per revolution	137.2
Gallons pumped in one hour	249,429.6
Gallons pumped per minute (displacement)	4157.1
Estimate slippage, 10%	415
Actual gallons pumped per minute	3742
Size of reservoir	250 x 22 ft.
Gallons in reservoir per inch	2437.5
Loss in reservoir in one hour	1 5/8 in.
Loss in reservoir in gallons	5586.5
Loss in reservoir per minute	93.1
Actual gallons pumped per minute	3649

In order to check the slippage of pump, a test was run on the reservoir with the wells alone, stopping the pump.

Time of test	15 min.
Water lift in reservoir increased	16 in.
Gallons pumped per minute	3666

Size of compressor used: Steam cylinder, 34 x 30; Air cylinder, 32 1/4 x 21 1/4; Stroke of all cylinders, 27 in.

Cu. ft. displacement in compressor per rev	23.77
Average revolution per minute	66.6
Cu. ft. free air per minute displacement	1583

3666 gallons per minute lifted 89.5 ft. equals 82.85 w.hp.

w.hp. divided by i.hp. equals 39.26% efficiency.

improved type, while the friction of the air in pipes, and slippage of water have been likewise affected by the design and selection of the well equipment. The losses, therefore, are those that we cannot expect to lessen substantially, due to the difference in temperature of the air at point of delivery and of application with the cold water.

Just what the fuel consumption of the air plant alone was we were not able to determine, but taken in conjunction with the steam pumps, which were forcing the same water against a head of 150 ft., the entire plant was handling on an average day approximately 5,700,000 gal. and consuming 12 tons of coal.

Given $2.60 as a fair price per ton, this would be about $0.005 per thousand gallons pumped. The result of this installation may well be considered a conclusive and demonstrable denial to contentions and assertions that the air-lift as a system is extravagant and uneconomical; for, given its proper sphere of operation and due care and provision in selecting and installing, results may be realized that permanently recommend and establish its use.

The above is much condensed from a paper in *Practical Engineering* by Mr. C. F. Ivins who superintended the installation of the plant described.

HEROIC TEST OF ELEVATOR AIR CUSHIONS

The passenger elevators in the Woolworth building, New York, are provided with efficient safety devices in the form of air cushions to prevent the shock of a sudden drop. Those who descend in these elevators are reminded of the presence and operation of these air cushions by the noise of the rush of air when nearing the bottom. The escape of the air is gradually diminished from the beginning of the cushioning effect until its completion. An elevator in the building was recently loaded with 7,500 pounds of pig iron, equal to the weight of 50 adults, and given a free drop from the 47th floor. The cushioning is said to have begun at the 11th floor; the carriage landed at the bottom as gently as could be desired and without rebound.

Four hundred locomotive repair shops throughout the United States, Canada and Mexico are now equipped for Thermit welding.

DISPLACEMENT VERSUS DELIVERY OF AIR COMPRESSORS

BY C. M. SPALDING.

The phrase "air compressor capacity" which is frequently used in correspondence and conversation is ambiguous and often misleading.

Air compressor capacity may mean piston displacement in cubic feet of free air per minute when working against any given gauge pressure; or it may mean the quantity of air delivered, expressed in cubic feet at atmospheric pressure; or it may even be used by some to mean the quantity to be delivered, expressed in cubic feet of air at the pressure at which it is intended to be stored or used. The word capacity should be avoided in this connection as it results in confused ideas, and some precise expression of the quantity of air desired should be used instead.

Air compressors are commonly rated by their piston displacement, or, when fully stated, by the piston displacement in cubic feet of free air per minute when operating against some stated gauge pressure. This is a value easily determined as it only involves the diameter of cylinders, the stroke, and the revolutions per minute of the crank shaft, when operating against the stated gauge pressure. It is used by all builders of reciprocating air compressors and is very convenient in determining, approximately, whether a given air compressor is suitable for a given service; but it is necessary to understand its relation to the delivery of the compressor in order to make such use of it.

The discussion which follows is limited to single acting compressors because electrically driven air compressors for railway service are ordinarily of this type. Let us consider the equation:

$$\frac{\begin{matrix}\text{Area of} \\ \text{piston in} \\ \text{sq. inches}\end{matrix} \times \begin{matrix}\text{Number} \\ \text{of} \\ \text{pistons}\end{matrix} \times \begin{matrix}\text{Stroke} \\ \text{in} \\ \text{inches}\end{matrix} \times \text{R.P.M.}}{1728}$$

= Piston displacement in cu. ft. of free air.

It should be understood that this result, while stated in terms of cubic feet of free air, is not a measure of a quantity of air at all, but only the expression of a volume, which may be filled with air at any pressure. As an example, if a compressor was used as a

vacuum pump it would have its displacement volume filled with air at approximately the pressure of the chamber which is being exhausted instead of with air at atmospheric pressure and temperature (free air). And, further, this piston displacement volume does not imply the delivery of the entire quantity of air corresponding to the piston displacement, but holds some relation to it which is explained in the course of this article. Finally, it does not include the gauge pressure at which the air is delivered; this pressure only being referred to because compressors when working against different pressures run at different speeds. In the case of a two-stage compressor, such as is used for the higher pressures required on the heavier locomotives, the low pressure cylinders only are used in the calculation.

The delivery, in cubic feet per minute, is a percentage of the piston displacement; this percentage is known as the volumetric efficiency of the compressor. It varies quite widely, the fundamental causes of this variation being the size of the compressor and its terminal gauge pressure at which the air is delivered. These causes will produce a considerable variation in the delivery of a series of compressors of different sizes, even though all are designed along the same lines with equal care; or in the same compressor when delivering air at various gauge pressures. Besides these there are other causes of variation in the volumetric efficiency which affect the results obtained, but which may be controlled and reduced to a minimum; among these are the volume of the clearance spaces, the type of valves, piston rings, etc.; much may be gained in efficiency by giving intelligent thought to these points in designing a compressor. Also the seating of valves, the fit of the piston rings, etc., are points where the workmanship becomes a very important item in producing the desired result.

This percentage of volumetric efficiency may be as high as 88 per cent. in a large two-stage compressor operating at 135 lb. gauge pressure or as low as 57 per cent. with the smallest single stage air compressors used for air brake service on street railway cars.

The gain in volumetric efficiency by two-stage operation over single-stage operation is due to the much lower terminal pressures in the low pressure cylinders of the two-stage machine, as compared with the terminal pressures in the single-stage machine. These pressures affect both the quantity of air left in the compressor clearance spaces and the amount of leakage past the piston rings and valves. The same relation between volumetric efficiency and terminal pressure may be observed when considering single-stage machines only. For example, if we take the case quoted above of the very smallest type of compressors for air brake service and operate it at 60 lb. instead of 90 lb. its volumetric efficiency becomes 66 per cent. instead of 57 per cent. It should also be understood that in the smaller compressors the clearance volume becomes necessarily a larger percentage of the total volume.

It is not proposed in this article to enter into a detailed statement of volumetric efficiency of various compressors, but to make some general statements showing why the delivery is less than the displacement. We will assume a compressor of 70 per cent. volumetric efficiency and state the approximate amount of the various losses which combine to account for the missing 30 per cent.

The intake air is never quite up to the atmospheric pressure from which it is drawn; that is, if we consider the atmospheric pressure as 14.7 lb. absolute pressure, then the air in the cylinder at the end of the intake stroke may be assumed to be 0.7 lb. less, or 14 lb. absolute, and this incoming air will be heated by contact with the walls of the cylinder head and cylinder to perhaps 12 deg. C. above the atmospheric temperature. Thus our quantity of air which might be contained in the cylinder and its clearance spaces is reduced to 91.5 per cent. of its value in free air before we begin to compress it.

The compressor must have a certain amount of mechanical clearance to prevent the piston striking the cylinder head, and to this volume must be added the volume of the ports which are provided for the passage of air from and to the valves. The combined volume of these items is the clearance referred to in the preceding paragraph when considered with reference to the air delivery. It is kept as small as possible by careful designing but must be consistent with a suitable area of air passages, and may be taken as from 2.5 to 3.5 per cent. of the total volume of the piston displacement plus clearance. In the comparison here made it is assumed to be 3 per cent. The speed

of the compressor is assumed to be 200 r.p.m.; that is, the compression stroke of each piston in a two-cylinder compressor occurs in approximately 0.15 sec. This time being so short, there is very little interchange of heat between the compressed air and the walls of the cylinder, which means that the air becomes very hot and the compression is nearly adiabatic. In addition to this it is necessary to carry our compression considerably above reservoir pressure for the purpose of lifting the valve, and it remains slightly above reservoir pressure after the valve is opened to induce the flow of the necessary quantity of air through the valve ports and the pipe to the reservoir, during this brief interval of approximately 0.04 sec. in which the valve is open. Our clearance volume is now filled with air at a pressure slightly above that in the reservoir. This air is left behind in the cylinder, when the piston begins its return stroke and the valve closes. Under the conditions stated, our clearance volume has become 14 per cent. of our total volume so that if there were no other losses we should have a delivery of 77.5 per cent., but we have still to account for the air which leaked past the piston rings and that which has leaked back past the inlet valve, these leakages should be, and are, kept as low as possible; but they exist in all compressors and must be taken into account. These piston and valve losses taken together represent the 7½ per cent. not already accounted for.

When the intake air separator, which is provided to remove dirt from the incoming air, is improperly installed so that dirt gets under the valves, the valve losses become very much greater and the delivery correspondingly less. For example, in one instance the writer when overhauling a compressor which had been in service several years increased its delivery 50 per cent. by simply taking it apart, washing out the valves and valve chambers and re-assembling.

Two or three other points may be profitably noted, which, although they are not a part of the statement of volumetric efficiency, should be kept in mind when considering the suitability of a given air compressor for a given service.

When compressed air is used in moving a piston in a cylinder it must be considered in terms of absolute pressure; for example, when an air brake piston is moved through an assumed stroke, dependent upon the mounting of the brake rigging, wear of shoes, etc., with a gauge pressure of say 50 lb.; the quantity of free air used would be expressed by the absolute pressure in atmospheres multiplied by the volume of the cylinder including its clearance in cubic feet: $\frac{50+14.7}{14.7} \times$ vol. in cu. ft. = quantity in cu. ft. free air. There is a very small temperature correction which may be disregarded.

When compressed air is to be measured as delivered to a tank or reservoir of known volume the procedure is as follows:

The tank ordinarily contains air at atmospheric pressure and temperature at the beginning of the test. Let us assume that we are going to fill it to 90 lb. gauge pressure; then we have at the end of our test a tank full of air at $\frac{90+14.7}{14.7} = 7.122$ atmospheres; that is, we have that many times its volume in terms of free air, except as affected by temperature, but it is usually at somewhat higher temperature than the surrounding air, and in this case the temperature correction should be included if close results are desired. For example, if the surrounding atmospheric temperature is 25 deg. C. or 298 deg. C. absolute and the temperature of the air in the tank is 40 deg. C. or 313 deg. C. absolute, then the air actually in the tank when it had cooled to the surrounding temperature would be reduced in absolute pressure to $\frac{298}{313} = 0.954$ of its absolute pressure at 40 deg. C. Its value for the cubic feet of free air, at atmospheric pressure and temperature, actually delivered after deducting the air in the tank at the beginning of the test would be

$[(7.122 \times 0.954) - 1] \times$ tank volume in cu. ft. = cu. ft. free air delivered.

It may be of interest to compare the relative values affecting the volumetric efficiency found for larger compressors of the double acting type, such as are used in stationary service, as given by Mr. E. A. Rix when discussing the same general subject in the Mining and Scientific Press. It will be noted that his figures include leakage through the piston rod

stuffing box, which feature does not exist in single acting compressors; and valve slippage or the shifting of the valve on its seat, which is so small an element in railway air compressor valves that it has been considered negligible. He takes as typical for the purpose of his illustration 70 per cent. volumetric efficiency when operating a single-stage compressor at 100-lb. receiver pressure. If the compressor were operating at 90 lb. pressure its volumetric efficiency would be 73 or 74 per cent. On the other hand he is considering a line of compressors of larger displacement, so that on the whole the conditions are sufficiently near to furnish us with an interesting comparison. His item of temperature losses includes losses due to the intake fall in pressure.

Railway air brake compressor single acting against 90 lb. gauge pressure.	Stationary air compressor double acting against 100 lb. gauge pressure.
Intake loss due to fall in pressure 4.8 per cent. Intake loss due to increase in temperature, 3.7 per cent.	Temperature loss, 7 per cent.
Clearance loss, 14 per cent.	Clearance loss, 16 per cent.
Piston loss, 7.5 per cent.	Piston and rod loss, 3 per cent.
Valve loss, 7.5 per cent.	Valve leak and slippage, 4 per cent.
Total, 37.5 per cent.	Total, 30 per cent.

General Electric Review.

MOVING PICTURES OF FLYING BULLETS

Moving pictures have unlimited possibilities apparently for the study of rapidly moving objects. An apparatus capable of making pictures at the rate of 100,000 a second has been made. With it seventy-two pictures of a revolver bullet were taken while moving ten inches. Pictures of a bullet passing through a stick of wood showed a curious condition. The bullet passed completely through the thin stick and was well on its way beyond before the wood gave any sign of distress. Then some tiny splinters started out, following the bullet; the stick began to split, and after the bullet had proceeded some distance the stick suddenly fell to pieces. No camera shutters are fast enough to take pictures at anything like this speed, so no shutter was used. Instead, a series of electric sparks was flashed, the sparks following one another at the rate of 100,000 a second, each spark making a picture. The film was mounted on a wheel about three feet in circumference, and the wheel was revolved at the rate of 9,000 revolutions a minute. When all was ready, the bullet was shot, the spark flashed and the wheel revolved, the actual exposure being limited to a fraction of a second so as not to pile up pictures one over the other.—*Machinery.*

UNDER WATER ROCK DRILLING ON THE TENNESSEE RIVER

"Professional Memoirs" of the Corps of Engineers of the United States Army and Engineer Department at large comprises valuable and authoritative accounts of engineering operations of widely varying character and location. Mr. J. E. Hall, assistant engineer, recently contributed to the above publication an interesting account, abstracted below, of work on the Tuscumbia bar which extends for a couple of miles in the Tennessee River 200 miles below Chattanooga. The bar is composed of a series of blue flint-limestone ledges overlaid with a thin coating of gravel, and the improvement project contemplated the excavation of a channel 150 ft. wide and 5 ft. deep, connecting the deep waters above and below the obstruction.

Extensive drilling being necessary in rock on top of which the depth of water varied from a few inches up to 5 ft., it was thought advisable to mount tripod drills on floats having sufficient buoyancy to carry men, drills and material to operate them and still be able to float in shallow water.

The floats used for the first season's drilling (1911) were composed of nine small boats, the dimensions of each being: Depth, 1 ft.; width, 5 ft.; and length, 25 ft. These were arranged in three rows, with three boats in each row, and a space of 2 ft. was left between the lines of boats through which to operate the drills. During the first season they were turned longitudinally across the current and the float was held in place with spuds 6 in.

square. When the boats were so arranged the floats were 19 x 75 ft. At each placing of the drill unit two lines of holes were drilled, extending half-way across the channel, and twelve holes were put down in each line. These lines being 7 ft. apart made the average spacing of the holes 6¼ x 7 ft., and the holes were put down to a depth of 7 ft. below low water.

DRILLING PROGRESS.

The drilling was carried on on this basis until Dec. 15, 1911, when it was terminated by high water and bad weather. During this season's work about 2500 lin. ft. of channel, beginning at the upper end of the work, were drilled and blasted. Where the detonation was perfect the rock was usually broken up, but often in such large pieces as to be very difficult to handle, and it was sometimes necessary to break them again with mud-capped shots before they could be handled.

Table 1 shows the 1911 season's work, giving the unit cost of drilling for each month, also the stage of the river, depth of water over the rock drilled and depth of the drilling in the rock.

TABLE 1—RESULTS AND COST OF WORK DURING 1911

Month	Lin. ft.	Average depth of holes, ft.	Gage, ft.	Depth of water over rock, ft.	Cost	Unit cost
August	3,520	4 to 5	.4 to 2	3 to 5	$1,336.60	$0.38
September ..	6,338	3 to 5	.3 to 1.5	3 to 4	2,871.20	.40
October	6,921	3 to 5	1 to 5	3 to 7	3,450.00	.50
November ..	10,373	4 to 5	1 to 3	2 to 6	4,634.39	.43
December ..	1,679	4 to 6	2 to 12	4 to 7	1,007.40	.66
Total	28,831				$13,299.59	

Average unit cost for season 1911, $0.46. Number of linear feet of channel drilled, 2,500.

Extensive repairs being necessary to the floats before entering on another season's work, it was decided to rearrange the boats composing them, turning them lengthwise with the current and leaving the opening between the boats 1 ft. wide. The floats used in the season of 1912 were composed of thirteen boats, 1 x 5 x 25 ft. long, put together in this way, making the spacing of the lines 6 ft. apart instead of 7, as in the previous year. The dimensions of this float were 25 x 77 ft.

At each placing of the drill unit or float twelve lines of holes were drilled, each line having six holes. As the length of the boat was 25 ft., the spacing of the holes was made 4 x 6 ft. and the holes were put down to a depth of 9 ft. below low water. In addition to the advantage of narrowing up the spacing, the placing of the boats lengthwise with the current was an advantage, in that they were less affected by the action of the current and drilling could be carried on at a higher stage of water.

TABLE 2—RESULTS AND COST OF WORK DURING 1912

Month	Lin. ft.	Average depth of holes, ft.	Gage, ft.	Depth of water over rock, ft.	Cost	Unit cost
June......	3,720	7 to 8	3 to 5	3 to 5	$1,523.19	$0.41
July......	3,256	7 to 8	3 to 6	3 to 6	1,465.00	.45
Aug.......	15,120	7 to 8	2 to 3	2 to 4	5,727.28	.38
Sept......	15,752	6 to 7	1 to 3	1 to 5	6,301.85	.40
Oct.......	20,250	5 to 7	1 to 2	2 to 4	9,317.50	.46
Nov......	20,042	5 to 7	.5 to 1.5	3 to 4	10,462.59	.52
Dec......	7,568	5 to 7	1 to 6	3 to 7	6,659.84	.88
Total...	85,708				$41,457.55	

Average unit cost for season 1912, $0.483. Number of linear feet of channel drilled, 2,500.

In comparing this season's work with that of 1911 it will be noted that the unit cost of the drilling is 2 3/10 cents in excess of the 1911 cost. This may be due to considerable advantage in weather and river conditions in 1911, and also to the fact that the drills were all new in 1911, while in 1912, especially near the close of the season's work, a number of them were badly worn and would not deliver a normal stroke. After September the cost is also augmented by the shortening of the days, making it necessary to work a longer number of hours at night. While the plants are very well lighted, quite a falling off is noted in their progress when comparing the result of an hour's work at night with an hour's work in the day. Early in October a number of the best drill men left the work to go back to their old stations at the furnace, and it was necessary to fill their places with new men.

ARRANGEMENT OF WORK.

The following method was universally followed during both season's work: The drill floats were placed in proper position for work by accurately lining them with ranges, marking the center of each half of the channel, and by cross-ranges which marked the lower extremity of the drilling and blasting already done. A float thus lined is in position for drilling one-half the width of the channel for a distance of 25 ft., or the length of the boats. At each setting twelve lines of holes were drilled, with six holes in each line. Each float carried eight drills, all of which are operated by steam.

To prevent the holes from filling with gravel and silt the drilling was done through tubing or pipe 3 to 4 in. in diameter. From three to five drill bits were used in putting down each hole, the first bit being 2½ in. in diameter and the last 1¾ in. When the hole was down to a proper length, a pipe that would exactly fit the top section of the hole was put in, the bit taken out and the hole loaded, the charge consisting of 80 per cent. gelatin dynamite and varying from six to ten sticks, according to the depth in the rock. The stick having the primer was placed about one-third of the way down from the top, having two or three sticks on top of it and from four to six under it. The charge was firmly packed down in the bottom of the hole with wooden poles which fitted very closely the section of the hole. When the loading was completed the hole was marked by a cane, which was firmly embedded in the charge, leaving the top about 6 in. above the surface of the water, and the primer wire was looped around the top of the cane. When all the holes were loaded the primers were all carefully connected so as to make three circuits, twenty-four holes to each circuit, leaving the end wires of the first and fourth line looped around the top of the cane so that they might be readily found and connected with the lead. The float was then dropped down from over the holes and a set of lead wires attached to each circuit. When these were connected (insulated tape being used for making all these connections) the float and tender were dropped back about 250 ft. below and the charges ignited by using three large batteries.

DRILL SHARPENER.

During the first season the drills were all sharpened by hand, but in 1912 a Leyner drill sharpener, operated with compressed air, was installed. A considerable saving was effected, as one blacksmith and helper were able to sharpen steel for twenty-four drills, while three blacksmiths and helpers were necessary to do this work by hand.

The seeming excessive cost of drilling here is due to the character of the rock, which is the very hardest of flint. It was found a very difficult matter to get steel that would stand this rock. The slightest mistake in tempering would cause the bits to fail at once.

COMPARISON OF WORK.

The season's work for 1912 covered the heaviest part of the blasting, as it began at the upper end of the extremely shallow water and extended entirely below it. While the number of linear feet of holes drilled in 1912 was about three times the amount drilled in 1911, only about the same channel area was covered, viz., 2500 lin. ft. This was on account of the narrow spacing of the holes, the additional depth drilled and the fact that this season's drilling covered the heaviest part of the work. There is now left above the dam an area undrilled about equivalent to 1200 lin. ft. of channel.

The average day's work for one drill unit operated with a double crew was 432 lin. ft.; average hour's work, 27 lin. ft.; average hour for one drill, 3 3/10 lin. ft.

TABLE 3—COST OF TENDER EQUIPPED FOR WORK

Building hull, cost of labor and subsistence	$1,346.66
Lumber and iron, nails, spikes, oakum, etc	1,902.40
Brownell boiler of 90 hp.	900.00
Leyner drill sharpener, No. 2	697.10
Compressor for running same	533.00
Receiver for air storage	64.80
Steam capstan	495.00
Setting up and connecting the above-named machinery	185.40
Building one-story cabin for sheltering machinery, material, and labor	465.00
Total cost of tender	$6,589.36
Type of float now in use, composed of 13 boats; cost, labor and material	1,140.00
Eight drills, E-24 Ingersoll-Sergeant	1,950.00
Steam hose, drill steel, iron pipe	365.00
Cost of float, equipped for drilling	$3,455.00
Cost of tender	6,589.36
Cost of one drill unit	$10,044.36

During the first season's work any boat having sufficient boiler power that could be spared from the plant was used as tender. The floats could be very quickly built, and they were put to work in this way pending the building of a suitable tender. The type of boat built for this purpose is a barge 30 x 80 x 4 ft., provided with three spuds. It is equipped with a 90-hp. boiler, a Leyner drill sharpener, a compressor for operating same, and a steam capstan for handling the barge. The sharpener is driven by air, the compressor in use being one manufactured by the Chicago Pneumatic Tool Company, having a 9-in. cylinder for steam and air, with 11-in. piston stroke, and a piston displacement of 130 cu. ft. of air per minute at 100-lb. pressure.

Three drill units were operated during the season of 1912, and it was found that one drill sharpener could keep steel in shape for the three units, each of which carried eight drills. Only one tender, as described in the

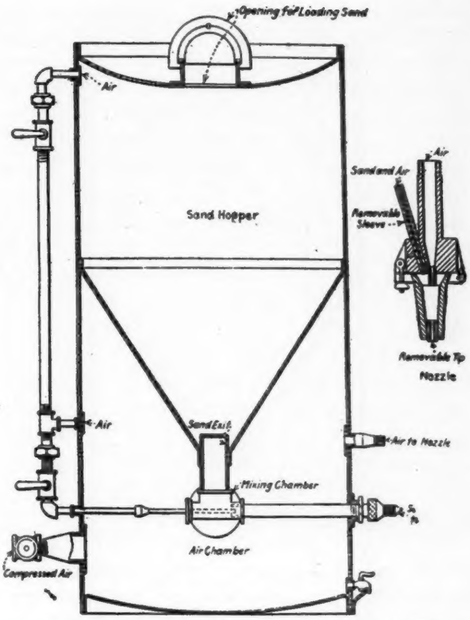
foregoing, has been built for the work here, the other two units being furnished with steam by spare pieces from the plant.

During 1911 28,831 lin. ft. of holes were put down, loosening up about 23,155 cu. yd. of material, costing as follows:

Actual field cost, including material, salaries subsistence, etc.	$13,299.59
Deterioration of plant on account of season's work	3,840.00
Overhead charges	664.98
Total cost	$17,804.57
Cost per linear foot	0.617
Cost per cubic yard, loosened	0.76

During the season of 1912 85,708 lin. ft. of holes were drilled and blasted, loosening up 76,185 cu. yd. of material estimated in place, costing as follows:

Entire field cost, material, etc.	$41,457.75
Estimated deterioration of plant	7,500.00
Overhead charges	2,072.88
Total cost	$51,030.63
Cost per linear foot, drilled and blasted	.595
Cost per cubic yard, loosened	.677
Total amount of material loosened up in the two seasons, cu. yd.	99,566
Total amount of dynamite used, 75,450 lb.	$12,855.36
Amount of dynamite per cubic yard, ¾ lb.	.127



HIGH PRESSURE SAND BLAST APPARATUS.

EVANS HIGH PRESSURE SAND BLAST*

Sand blast machines have been in more or less successful use for many years, the first device of the kind having been patented in or about the year 1870. This was followed by several others, all of which have been utilized chiefly for cleaning stone buildings, soft iron and brass castings. These machines are all of the single hose type; they have been tried in removing old paint and rust from metal structures, and as found by experts in operating at a low pressure it took a long time and did not remove the rust or paint completely, leaving it on in spots. As soon as sand blast machines had been in use for a few years the United States Navy Yard in Brooklyn, in 1897 cleaned, or attempted to do so, the man-of-war Brooklyn. The work was not satisfactory to the Government and I believe has never been tried since then on U. S. Government ships. It has, however, been in use to a certain extent in foundries of the navy yards. It remained for the Evans high-pressure sand blast machine to be the first machine which ever successfully cleaned steamships, which was done at the Cramp shipyard in May, 1912.

Bridge engineers became deeply interested in the question of sand blasting structural steel, because the mill scale, which is on all structural steel, must be removed before the first, or shop, coat of paint is applied, otherwise corrosion is bound to take place and the I-beams will become gradully eaten up by rust. This rust operates on steel exactly as a cancer on a human body and undoubtedly many railroad wrecks, which have occurred on bridges even when incased in cement, have been directly from the effect of the corrosion of the steel beams. We have proved beyond the peradventure of a doubt that wherever mill scale is not removed even under paint, when exposed to weather or dampness, and even when incased in cement that a chemical action does take place, and the structure is thereby enormously weakened. While this may not be of great interest to you gentlemen of the foundry trade, still it shows the necessity of using a sand blast on steel or iron whether it be structural material or castings which enter into the general manufacturing business and uses for the general trade.

*From an address by David Sands Ferris of the Carter Metals Cleaning Company, Philadelphia, before the Associated Foundry Foremen of Philadelphia, Oct. 8.

Right here a further word in regard to the composition of mill scale, or at least of its characteristic porous inner layer, which makes it possible for corrosion to attack the steel and loosen the scale-forming centers from which rust will extend. Mill scale forms in two layers, the inner one being represented by the formula $6\,Fe + Fe_3\,O^4$, and is very porous and brittle. The outer layer contains a larger but varying proportion of Fe_2O^3. The air and moisture contained in this porous scale tends to destroy the paint spread over it by starting corrosion. This scale is magnetic. A galvanic action is said to be set up around the edges, and corrosion commences there and afterward extends under the scale and outward under the paint. It is very important, therefore, that the mill scale be removed by some efficient means before the first coat of paint is applied.

With this digression I shall return now to the Evans high-pressure sand blast machine as applied to foundry work on both iron and steel castings. The machine is operated under a high pressure of from 90 to 100 lb. and will maintain steadily this or any desired pressure. This is rendered practical as the Evans uses a double hose connected at the nozzle, where the sand and the compressed air unite, each being brought to that point independently of the other, so there is no loss of pressure from friction. The free air passes through a turbine high velocity jet 3/16 in. in diameter. The turbine principle, as you are all well aware, has developed the very highest type of steam engines, and it is this principle as applied to air, which we have adopted in our machine. The compressed air being expanded in the nozzle through this turbine high velocity jet, projects the sand from the end of the nozzle with a velocity of from 1200 to 1500 ft. per sec. The discharge in cubic feet of free air at the following pressures will show its great efficiency and the fact that it uses not more than one-quarter of the air of any other single hose machine:

Discharge of Air Through 3/16-In. Turbine Jet.

Air. cu. ft.	Pressure, lb.	Power required, hp.
60	80	11.8
76.5	90	15
83.8	100	17.5

This great saving in air means a corresponding saving in horsepower. Again, the pressure is constantly maintained owing to the fact that the air which passes through the turbine jet, which is 3/16 in. in diameter, can never vary. This jet will never increase in size as it is recessed back in the nozzle where the sand is forced through the sand and air hose into the mixing chamber or removable cone in the nozzle. The sand is then forced out through the tip of the nozzle by the pressure of air through the turbine jet, acquiring there a centrifugal or spiral motion which causes the sand to whirl and this motion going out through the tip of the nozzle at a high velocity strikes the object which is to be sand blasted and not only by the direct play of the stream of sand, but by the whirling motion, it scours off any scale on the castings caused by the flux or otherwise. This constant flow of air is of the very greatest importance not only from the standpoint of economy, but also from the standpoint of efficiency, as it will clean a given surface more rapidly than other machines, and will not use as much sand.

On the other hand, single hose machines will start with a nozzle opening of 3/8 in. and will increase this opening, thereby increasing the flow of air and sand, which, of course, is caused by the fact of the sand and air passing out at the end of the nozzle. The sand wears out the nozzle very quickly and also the friction lessens the pressure and increases the horsepower required.

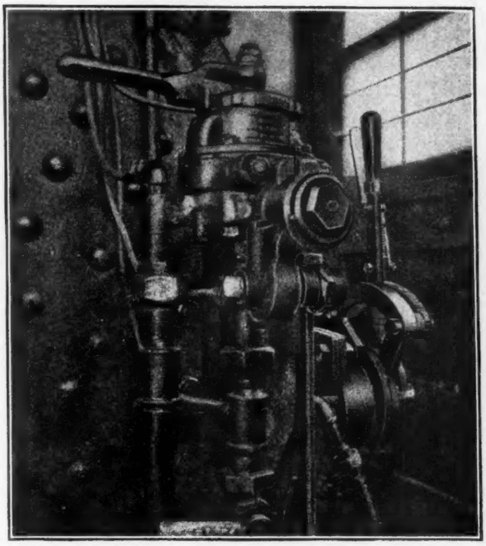
In conclusion there is no doubt that the numerous sand blast machines, which were originally designed for low-pressure machines, have been improved in every possible way to a high-pressure machine except at the one salient and important point, the nozzle, and the fact that they are and always will be single hose gives the double hose machine an enormous advantage. The principles which I have endeavored to explain to you I may say are basic principles, and, as applied to-day by us, show such wonderful advantages as will enable us to build machines which are adaptable for every kind of use where sand blasting may be used.

The quantity of natural gas necessary for the production of a ton of steel ingots by the open hearth process is about 5,500 cubic feet, having a heat value of 5,766,750 b. t. u.

A NEW POWER REVERSE GEAR FOR A LOCOMOTIVE

The reversing of a heavy locomotive requires considerable physical strength, and when the operation has to be frequently repeated the suggestion of the use of mechanical power for the purpose is inevitable, and many arrangements have been devised for the purpose. It is becoming generally recognized by railway men that locomotives in switching service, equipped with power reverse gear, can handle a much larger tonnage than those without it, and as an adjunct to the efficiency and comfort of the crew, such equipment cannot profitably be overlooked.

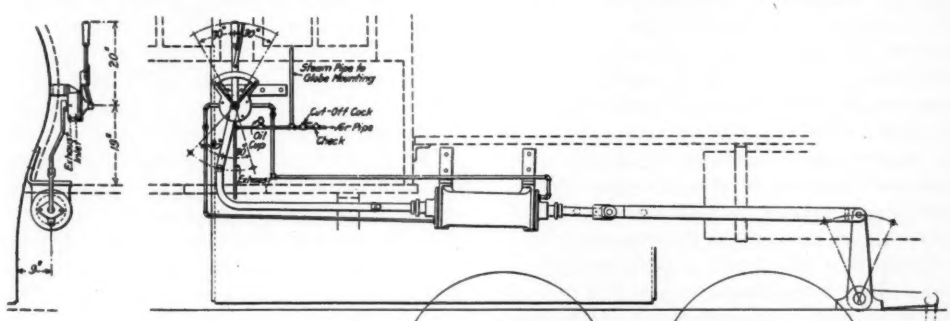
The two illustrations here reproduced from *Railway Age Gazette* show the essential features of the Casey-Cavin reverse gear recently introduced by the Canadian Locomotive Company, Ltd., Kingston, Ont., and for which patents are pending in several countries.



REVERSE GEAR IN CAB.

The illustrations show the general arrangement and also the controlling valve and lever in the cab. This application was made to some 0-6-0 type switching locomotives for the Canadian Northern.

The device consists essentially of a cylinder containing a piston, and rods so arranged as to shift the links or radius bars, and a valve containing two independently movable discs, one operated by the hand lever and the other by the connecting bar from the piston. These valve discs are so ported and arranged that on a movement of the hand controlled disc, pressure is admitted to one end of the cylinder and exhausted from the other end, thereby producing a movement of the piston which brings the ports in the other disc to the same relation that they originally bore to the hand controlled disc. After either a complete reversal or only a "hooking-up" of the motion, the pressure is held on both sides of the piston, thereby locking it at any point. From this it will be seen that should any excessive strain be set up in the reach rod, causing a movement



GENERAL ARRANGEMENT OF REVERSE GEAR.

of the piston, a compensating admission of pressure would take place on the opposite side of the piston. The point of cut-off is indicated by the position of the lever on the quadrant, corresponding to the hand type of lever, thereby guarding against confusion to inexperienced enginemen.

The cylinder is compact and can readily be attached to the boiler, firebox or running board in a substantial manner without interfering with other parts of the locomotive. The space occupied in the cab is very small, the travel of the handle being about 16 in.; the maximum pull necessary is from 12 to 15 lbs. The device is preferably operated by air pressure, but provision is made for the use of steam in the event of trouble with the air system. The total weight of the gear for a simple locomotive is about 375 lbs., and for a Mallet about 500 lbs.

Reports from applications made thus far are extremely satisfactory and seem to indicate that the device fills a long felt want, as it is reliable and at the same time so simple that it adds little or nothing to the cost of maintenance. A gear designed on similar lines and equipped with a positive mechanical locking device has also been developed by this company for fast passenger locomotives.

THE ONE-MAN DRILL*

It may be stated generally that in the Lake Superior copper district the average copper content of the rock decreases with depth. This has been the history of the district, and the cost of mining increases proportionately with depth. The Michigan copper mines are operating on rock containing lower copper content than the other copper-mining districts of the United States, and the Michigan copper mines are operating at greater depth, and consequently at greater cost, than the other copper mines of the United States. In order to compete, it is absolutely imperative that the mines of Michigan should be operated with the closest economy. The operators in Michigan have attempted to practise their greatest economy in the way of improved machinery and equipment, and the greatest step that has been made in this direction in recent years is the installation of the one-man drill. A statement made by the superintendent of one of the mines, is as follows:

"The necessity for further close economy in the operation of our mine forced us to go into the market for a more efficient drilling machine, and, if possible, a machine that could be operated with one man as compared with two, which was standard practice. After about 18 months of experimenting the present machine was adopted. Our intention was to divide the benefits accruing to us from the use of the one-man machine with the men; this benefit to take the form of higher wages to machine operators (called miners). That this plan has been carried out is shown by the following table, which shows the increase in wages to the men operating one-man drills over wages made when operating two-men drills.

COMPARATIVE STATISTICS OF ONE-MAN DRILL AND TWO-MAN DRILL, CALUMET & HELCA AND SUBSIDIARY MINES, FOR THE YEAR ENDED DECEMBER 31, 1912.

	2-man drill.	1-man drill.
Shifts	350,012	54,758
Labor cost	$1,024,801.84	$193,935.81
Supplies	291,526.14	94,058.24
Total	1,316,327.98	287,994.05
Average wage per shift	2.83	3.34

"The miner's wages largely depend upon the efficiency of the man, as our work is all on the bonus system, and is so arranged that increased efficiency is of mutual benefit to the employer and the employee. We have a fixed contract which is not cut as the efficiency of the employee increases.

The committee made some inquiry as to how the one-man drill is received by miners in other copper districts, especially the Bisbee district of Arizona, and quotes from a letter received by it under date of September 29, 1913, from one of the mining engineers of the property of the Calumet & Arizona mine:

"The Company has in operation at the present time 100 one-man drills, which is 90 per cent. of the total number of drills now on development work. Sixty-five of these drills were purchased during the last four months. The one-man drill will no doubt replace all other larger drills in the near future.

*From report of Copper County Commercial Club.

COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

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W. L. SAUNDERS, - - - - - - - - Editor
FRANK RICHARDS, - - - Managing Editor
CHAS. A. HIRSCHBERG, - - Business Manager
W. C. LAROS - - - Circulation Manager

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CONTENTS

THE ATMOSPHERE THE UNIVERSAL WATER CARRIER

Among the most important of the atmospheric functions is the transportation and distribution of water over the earth. It not only spreads the water widely, but, to sustain this operation it must also somewhere be constantly picking up or absorbing in no less average quantities the water which it carries and delivers; and thus the air is, as circumstances may determine, not only a humidifier but also a desiccator. It not only wets things but it is equally able and ready to dry them when the conditions are reversed, and we may learn to profitably employ it for either service.

The changeable and controlling conditions spoken of are those of pressure and temperature, and especially the latter so far as the atmospheric transfer of moisture one way or the other is concerned. The various and unending changes of the weather, with which we are all our lives so familiar, are the resultants, or the accompaniments, of changes of atmospheric pressure or temperature, or usually of both; and the wonder must constantly be that so slight natural changes of these controlling conditions can produce results of such magnitude and extent. When we attempt to employ these atmospheric agencies for our industrial or other purposes we have to vastly exaggerate or intensify the changes in temperature or pressure which nature employs to enable us to accomplish results of any appreciable value.

The atmosphere never shows any let up in its water trading activities. Although it may never be said to be absolutely "dry" it absorbs water with avidity from almost anything that is "wet" with which it may come in contact, until the point of saturation is reached, and then the absorption suddenly ceases; but then it may be in condition to immediately reverse the process and become a dispenser of moisture, the dew-point being a point of unstable equilibrium.

In connection with the water carrying habit of the air we strike a curious paradox to which attention might be more generally directed with the purpose of leading to a better understanding of the phenomena involved. When at any time it happens to be evident to our unaided senses that there is an abnormal proportion of moisture in the air, or when the weather bureau is reporting that the percent-

age of humidity is high, it is commonly said that the air is heavy, or "laden with moisture," and the paradox is that the moister the air the lighter it is, and that dry air is the heaviest of all.

Say that we compare a cubic foot of dry air with a cubic foot of air saturated with moisture, assuming the air to have the same pressure and temperature in both cases. It is natural and easy to assume that the latter volume is the same as the former so far as the air is concerned, and that the water has in some way gotten into it, the weight of the water therefore being added to that of the air, which of course must make the total weight of the mixture greater than that of the air alone.

The simple fact—and not so simple after all —is that, although the water is so intimately and completely intermingled with the air, it still exists in the form of true vapor and occupies its due share of the space as such, displacing thereby so much of the air, and as water vapor alone is decidedly lighter than air alone so must any volume composed partly of air and partly of water vapor be lighter than an equal volume composed entirely of air.

FOREIGN LAWS FOR COMPRESSED AIR WORKERS

The following letter, reprinted from *Engineering News,* Sept. 18, will explain itself. It refers to the letter of Mr. Richards, reprinted at page 7001 of COMPRESSED AIR MAGAZINE, October, 1913. The new law referred to is at page 6998 of the same issue:

Referring to the New York law governing work under compressed air and to Mr. Frank Richards' letter about an oversight in said law in regard to proper ventilation of the lock during the period of decompression; it is evident that if the men were not taken dead out of the lock, as Mr. Richards fears, they would surely feel nauseated or have all the symptoms of the first stages of asphyxiation after spending half an hour or more in a crowded lock without ventilation.

As Mr. Richards states, the condition of the air in the heading of a tunnel may be expected to be much better than in a caisson, particularly so if the face is fairly open. This seems to be about the only reason [It looks like a kind of left-handed reason in this case. Editor C. A. M.] for the law to call for 24 min. for decompression from a 36-lb. pressure and 40 min. from a 40-lb. pressure in a tunnel, whereas it calls for 20 min. for decompression from a pressure of 36 to 40 lb. when work is done in a caisson. Otherwise, it would seem that owing to cramped space and other disadvantages of the caisson work the men ought to be required to take more precautions and to spend more time in locking out than the men working in a tunnel.

The laws of the Netherlands and those of France regulating work in compressed air are more specific and more complete in so far as they relate to locking in and out and as to the lock itself. Article 28 of the Netherlands Regulations states that:

The lock must have an interior height of 1.80 m. and a floor area of 0.30 sq.m. per man up to a pressure of one atmosphere; of 0.35 sq.m. per man for a pressure of from one to two atmospheres and of 0.40 sq.m. per man for a pressure greater than two atmospheres; in the latter case benches must be provided so that the men may sit down.

Article 29—The ventilation of the lock shall be properly provided for.

Article 30—At the bottom of the lock shall be a removable perforated floor.

Article 31—Men shafts shall not be obstructed by tubes or pipes of any description.

Article 32—The lock shall be cooled or heated as the case may be unless means have been adopted to prevent the exterior temperature from having any direct influence thereon.

The French Law, enacted on Dec. 17, 1908, states:

Article 7—The volume of air per man in the lock will never be less than 0.6 cu.m. for any head of water up to 20m. and 0.7 cu.m. for any greater hydrostatic head.

The ventilation of the locks, during decompression lasting more than 10 min. shall be obtained by working simultaneously the valves controlling the inelt and outlet of the air to and from the locks, such valves being of different sizes.

In summer the locks exposed to the sun shall be protected by a tent or by straw mats sprinkled with water.

The supply of air will be such that the amount of carbonic acid in any sample of air taken at the longest distance from the point of delivery of the air pipe will not be greater than 1.5 in 1000 for pressures under two atmospheres and one in 1000 for higher pres-

sures; this percentage to correspond to a supply of 30 to 40 cu.m. of pure air per hour per man.

A sample of air will be taken and analysis thereof made whenever the supply of air will fall below 40 cu.m. per hour.

The passage through the lock during the decompression is often uncomfortable and this explains the haste with which the men are anxious to lock out. The proper ventilation of the lock will improve the quality of the air as well as prevent condensation to some extent.

This condensation and the resulting cold are chiefly objected to by the workmen, and this seems plausible enough since instances have occurred when the temperature dropped from 36 degrees C. to 5 degrees C. This condensation, however, is due to a rapid decompression; when this decompression is effected uniformly and at a speed of one-tenth of an atmosphere per minute, there is no appreciable condensation and hardly any drop in temperature, this lowering of temperature being opposed by the radiation of 300 to 400 calories given by the men, figured at an average of 75 calories per man per hour.

The French Law has not prescribed, as does the Dutch Law, the distribution of woolen clothing to the men when locking out, but requires that such recommendations as to clothing and other hygienic measures be printed and posted in the locks and about the works.

The great difficulty is to reconcile theoretical regulations and practice, and to convince the men of the necessity of using discretion in locking in and out. In view of the unwillingness of the men to spend the theoretical specified time in the lock, I found that the best way was to strike some happy medium by fitting the inlet and outlet valves with blank flanges, perforated in such a way that even by opening these valves in full, the time spent for compression or decompression would not be less than, say one-half to two-thirds the specified time and for long decompression to keep the exhaust valve open wide and the inlet valve partly open proportionately to the pressure and the theoretical time of decompression.

PAUL SEUROT.

Montreal, Can., Sept. 6, 1913.

"PRODUCTIVE" AND "NON-PRODUCTIVE"

Apparent absurdities frequently occur in our classifications of the productive and the non-productive in industrial operations. What is characterized as non-productive is always to be regarded deprecatingly, and economy is always to be assumed when the ratio of it to the whole is reduced; but how can anything, labor for instance, which is absolutely necessary in the orderly and profitable conducting of a business be called non-productive? There may not be any who would call the steam engine productive and the boiler non-productive, but they come near such foolishness in some other lines of record. The following from an esteemed contemporary, and for which it is not responsible, embodying definite and valuable information as to detail of mine operation is a sample of the general practice:

"The ratios of productive to non-productive work in some of the Butte shafts are as follows: Speculator, 1:2.12; Diamond, 1:1.52; High Ore, 1:3.34; Mountain View, 1:2.22 (A. I. M. E. Bulletin, September, 1913). These figures represent the ratio of effective horsepower developed in hoisting ore to effective horsepower developed in hoisting men and material. The greater consumption of horsepower in non-productive work is largely due to the fact that such operations are conducted out of balance and the dead load of skip, cage and rope is exceedingly heavy."

If the non-productive work of hoisting and lowering men and material should stop how much productive work would there be?

DISCOURAGING THE USE OF OZONE

An adverse report upon the properties of ozone has been made as a result of scientific investigations conducted on behalf of the official organ of the American Medical Association, by eminent bacteriologists. The report states that so far as the evidence goes, ozone produces no reaction in the human organism that can be regarded as in any degree beneficial in warding off infectious disease. On the contrary, all appreciable physiological changes produced by the inhalation of ozone are distinctly of an injurious and weakening character. The report goes on to say that while it is true that some bacteria are nudoubtedly killed by ozone, especially if they are in a moist condition, and are in contact

for several hours with a current of ozone coming direct from the generator, the fact is of slight importance in practice. Human beings are injuriously affected by amounts of ozone far less than are necessary to produce even this slight bactericidal effect, and there is no evidence for supposing that, a quantity of ozone that can be tolerated by man has the least germicidal action. On the contrary, in concentrations that appreciably affect man and animals, ozone appears to have uniformly an injurious action, especially on the respiratory organs. Another objection to the use of ozone as an "air purifier" is that, while it has the property of masking bad odours, it destroys neither their cause nor effect. Since bad odours are danger signals, anything which tends to conceal them is obviously not in the best interests of hygiene.

NEW BOOK

Compressed Air Practice, By Frank Richards, McGraw-Hill Book Company, New York, IX+236 pages 6 by 9 in., nearly 100 illustrations, including full page half tones, numerous tables. Price $3.00.

This book, by the managing editor of Compressed Air Magazine, is different from all the other books on the subject. It is not a learned book; it is easily readable and understandable; it is written for the many rather than for the few, for those who know little about air rather than for those who mostly know all that is known about it. All air is compressed air, as the book assumes, and it has intimate relations not only with the vapor of water, which it always carries, and its own constituent gases, but with all the gases industrially employed, and air compressors find work in their manipulation, so that there is unlimited reach to the general subject. The titles of the chapters are strung together below:

Atmospheric generalities, Definitions and general information, The compressed air problem, Tables and charts for computations in air compression, The indicator on the air compressor, Single-stage compression, Two-stage compression, Two-stage and three-stage compression, Compressor regulating devices, The drive of the compressor, The turbo compressor, The Taylor compressor, Humphrey pump, Power cast of compressed air, Power from compressed air, The air receiver, Pipe transmission, Reheating compressed air, Compressor and receiver fires and explosions, Side lines for the air compressor, Natural and artificial gas transmission, Gasoline by compression, Liquefied natural gas, Rock drill developments, Electric-air drill, Compressed air for raising water, Air-lift, Air for large stone hammers, Diving bell and caisson, Air jet, sand blast, cement gun, Liquid air, oxygen and nitrogen from the atmosphere.

THE NEW STANDARD DICTIONARY

Funk & Wagnalls' New Standard Dictionary of the English Language, the greatest of all the books, which has lately come as a permanent and valued addition to our reference table, is great in so many ways that it is not easy to determine where to begin to talk about it.

It is great in weight, 20 lb.; and in bulk, 600 cu. in. There are 3000 pages, 9 by 12 in., including inserts not numbered; there are 7000 illustrations, full page, double page, many in colors, and smaller cuts more than double as many as all the pages. The cuts are not inserted for pictorial effect or to promote the sale of the book, but are all pertinent to and explanatory of the text, making many things clearer to the inquirer.

The book is a monument and a not unworthy representative of the growth of thought and activity as exemplified in our written and spoken language to-day. The first regular English dictionary, Bailey's, which appeared nearly two centuries ago, contained 15,000 words, while the present Standard has thirty times as many, and dictionaries do not grow merely by adding words from time to time, but must be rewritten over and over again. We want not merely all the words, both old and new, but we must have more copious definitions of the words, more information of the use of them and of their relations. We scarcely needed to be told of the host of learned specialists and of the time that they have worked to produce this new book, because the evidence and the result of their labors crowds every page.

The book is made to be constantly used, and readiness and convenience are not least among its noticeable characteristics. There is an alphabetical arrangement which includes all the words, both the common words of the regular language and all the proper names, historical,

geographical, ultra-scientific, and the rest, so that there is no searching in different sections when a word or a name is wanted. You either find it at once or you don't find it, if that could happen, and whatever it is when found you are told just what you want to know about it, with almost invariably something which you did not know before. The dictionary is a great acquisition, as it must be to everyone who gets hold of it.

MASSACHUSETTS AIR RECEIVER INSPECTION LAW

The following is the substance of a newly-enacted law in Massachusetts, providing for the inspection of air receivers. The law has to do only with the use of compressed air for pneumatic tools and machinery:

1. No person shall install or use, or cause to be installed or used, any tank or other receptacle exceeding 18 inches in diameter for the keeping or storage of compressed air at any pressure exceeding 50 pounds per square inch for use in operating pneumatic machinery, unless the owner or user thereof shall hold a certificate of inspection issued by the boiler inspection department of the district police, certifying that the said tank or other receptacle has been duly inspected within two years, or unless the owner or user shall hold a policy of insurance upon the said tank or other receptacle issued by an insurance company operating under the laws of this commonwealth, together with a certificate of inspection from an insurance inspector.

2. The board of boiler rules shall prescribe regulations for the size, shape, construction, operation, minimum pressure, gages, safety devices and other appurtenances necessary for the safe operation of all tanks or other receptacles used for the storage of compressed air, except those exempted in section 7 of this act.

3. The boiler inspection department of the district police shall inspect all of the said tanks or other receptacles exceeding 18 inches in diameter and in excess of 50 pounds pressure per square inch at least once every two years; provided, however, that the said department shall not be required to inspect such tanks or other receptacles as may be covered by a policy of insurance and inspected by insurance inspectors.

4. All owners of any of the said tanks or other receptacles exceeding 18 inches in diameter and in excess of 50 pounds pressure per square inch shall notify the chief of the district police of the location of the same.

5. Every insurance company authorized to insure air tanks within this commonwealth shall forward to the chief of the district police, within 14 days after each internal and external inspection of an air tank or other receptacle a report of such inspection. The reports shall be made on blanks furnished by the chief of the district police, and shall contain all orders and regulations made by the company regarding the air tanks or other receptacles so inspected.

6. The inspection shall consist of a hammer test, and also a hydrostatic test, the pressure of which shall be one and one-half times the pressure allowed on the air tank or other receptacle inspected. The air tank or other receptacle shall be prepared for inspection by the owner or user thereof.

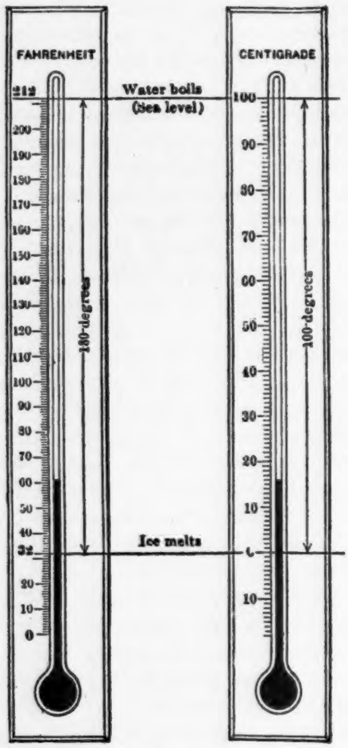
7. The provisions of this act shall not apply to tanks or other receptacles used for the keeping or storage of compressed air when attached to locomotives, street or railroad cars, vessels or motor vehicles.

8. The sum of $3 shall be paid to the boiler inspection department of the district police by the owner or user of any such tank or other receptacle for every inspection thereof by the said department herein provided for.

9. Whoever violates any provision of this act, or any regulation made under authority hereof, shall be punished by a fine not exceeding $50, or by imprisonment for not more than 30 days, or by both such fine and imprisonment.

CENTIGRADE AND FAHRENHEIT

The cut on the next page from *Coal Age*, if kept in sight, should serve as a handy reminder of the relations of the two scales. It is not necessary to go into the figures here as they are to be found in all the pocketbooks and elsewhere. It may be worth while to remind our readers that the Fahrenheit scale is nearly as much a centigrade scale as the other. Fahrenheit took the temperature of a mixture of salt and ice, the lowest then attainable, for his zero, and the temperature of human blood, as nearly as he could determine it, he made 100 degrees, and there you are.



THERMOMETERS COMPARED.

NOTES

The largest stone ever quarried has been found at Baalbec in Syria. It is 69 ft long, 14 ft. wide and 17 feet deep, and is estimated to weigh 1,400 tons.

The weight of the oxygen of the globe exceeds that of all other elements combined. It forms by weight about three-fourths of the animal, four-fifths of the vegetable, and one-half of the mineral worlds; also one-fifth by volume of the atmosphere and eight-ninths by weight of water.

Electricity, unlike other commodities, cannot with justice to the producer be sold at so much per unit regardless of who buys it or when he buys it. This is due to the fact that with respect to every customer the cost of producing it varies with the hour of the day and the nature of the customer's load.

An oil for use in exposed places in the winter time is produced by mixing graphite with cylinder oil until the mass assumes a pasty consistency, and then adding enough kerosene to reduce the mixture to a freely flowing liquid. It is claimed that the oil thus produced will not stiffen in an atmosphere at the temperature of 14 degrees below zero.

According to *"Wasser und Wegebau Zeitschrift"* a new European record in tunneling was made last August in the building of the Swiss Hauenstein tunnel. The previous record was set in July, 1909, when 1013.5 ft. were broken out in the Loetschberg tunnel. The present record shows 1051.9 ft., thus exceeding the previous one by 38.4 ft.

Price of natural gas for domestic purposes in various states is as follows, in cents per 1000 cu. ft.: West Virginia, 18.12; Pennsylvania, 26.02; Ohio, 27.40; Kansas, 22.82; Oklahoma, 16.88; New York, 30.39; Indiana, 29.92; Louisiana, 22.84; Illinois, 22.85; Keutucky, 30.57; Texas, 39.73; and Alabama, 22.84 cents.

Hartford is the fourth city to return to the manuafcture of coal gas in place of the water gas which has been used for a number of years, a discontinuance of which is being forced by the high price of petroleum. Derby, Ansonia and New Haven have already installed coal gas plants in place of those discarded some years ago, and the manufacture of coke has been resumed.

One of the first bores put down in Western Queensland to tap the great artesian storage in the interior of Australia was at Thargomindah, and the water from it is now being put to a novel use. The pressure is 270 lb. to the sq. in., yielding about 670,000 gallons per day. The bore is 2560 ft. deep, and the temperature of the water is 166 degrees, It drives a water wheel at 1200 r.p.m. to provide power for the local electric light system.

Little progress has been made in the United States in the use of ozone for water purification, owing to the excessive cost of the process. There are eight large cities in Europe using ozonated water, wherein the daily aggregate consumption is 39,600,000 gallons. The average cost of treatment is $10 per 1,000,000 gallons. A small plant, having a daily capacity

of 80,000 gallons has been installed at Great Falls, S. C. It is claimed that the cost of treatment there does not exceed $5.00 per 1,000,000 gallons.

It is understood that a great precooling, ice-making and refrigerating plant is to be built at the outer harbor of Los Angeles, to supply ice for harbor purposes, icing ships, etc., and to furnish cold storage facilities at the harbor.

A poultry man of Waltham, Mass., is using electric ozonizers to reduce mortality in the hatching and brooding of chicks. Ordinarily 24 to 40 hours elapse from the time the first chick peeps forth from its shell until the last one appears; but the use of ozone invigorates the chicks, as indicated by a recent hatching, which came out in ten hours. Furthermore, the chickens are uncommonly strong and robust.

We talk lightly of high vacua, or even of a perfect vacuum, says the *Scientific American.* It is instructive to calculate the number of molecules contained in a cubic millimeter of gas at the lowest pressure on record. W. Gaede has recently succeeded in exhausting a vessel to a pressure of two ten-millionths of a millimeter of mercury (four one-thousand-millionths of a pound, .000,000,004, per square inch). At this pressure one cubic millimeter of gas would still contain about 8,500,000 molecules.

The commissioners of northern lighthouses, Edinburgh, have in their charge ninety lighthouses on the coast of Scotland. Up to the year 1900 the revolving lights were borne on rollers. The "float" system has been gradually introduced, however, and is now in operation at thirty coast stations and will be used at all others. The lighting machinery rests on a pontoon which runs on quicksilver in a groove. The quantity of mercury required for this purpose in a lighthouse is from seven to eight flasks of seventy-five pounds each. As the waste is trifling, the total present demand for this purpose is after all comparatively small.

The following is from the records of hoisting speeds in some leading British collieries: Dowlais Mine, Cardiff, 2,220 ft. in 52 seconds, an average winding speed of 2,562 ft. per minute; Ashton Moss Colliery, 2,850 ft. in 1 minute 25 seconds, or 2,010 ft. per minute; Lady Windsor Colliery, 1,500 ft. in 35 seconds, or 2,571 ft. per minute; Bolsover Colliery, 1,116 ft. in 28 seconds, or 2,388 ft. per minute; Denaby and Cadeby Collieries, 2,289 ft. in 55 seconds, or 2,497 ft. per minute; Rhodes Rotherham Colliery, 1,650 ft. in 45 seconds, or 2,358 ft. per minute; while at the Rosebridge Colliery, a maximum hoisting speed of 5,100 ft. per minute has been recorded; but this is excessive, as, for considerations of safety, it should not exceed 4,000 ft. per minute.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

OCTOBER 7.

1,074,601. AIR-BRAKE. Robert D. Buswell, Wellington, Kans.

1,074,608. AIR SUCTION AND FORCE PUMP. Franklin O. De Hymel, San Antonio, Tex.

1,074,744. VACUUM-CLEANER. Herbert T. Rodden, Chicago, Ill.

1,074,795. GAS-TESTING APPARATUS. Einer Johnson, Minneapolis, Minn.

1,074,797. PRESSURE - OPERATED DEEP-WELL PUMP. Paul G. Kaiser, Chicago, Ill.

1,074,890. PNEUMATIC-CARRIER SYSTEM. Frank W. Nelson, Chicago, Ill.

1,074,903. VACUUM-DRIER. Oliver S. Sleeper, Buffalo, N. Y.

1,074,920. PNEUMATIC CLEANER. Ernest E. Yaxley, Chicago, Ill.

1,074,934. SYSTEM OF STORING AND CONVEYING INFLAMMABLE AND OTHER LIQUIDS. Hermann von Eicken, Friedenau, Germany.

1. In a system for storing or conveying liquids *with the aid of a pressure fluid,* the combination of a container having a safety outlet for said pressure fluid and adapted to contain said liquid, a jacket surrounding a portion of said container, a connection between said jacket and said safety outlet, and a body of sealing liquid contained in said connection and adapted to normally close said outlet, but to open it in the event of the jacket's leaking.

1,075,014-21. STATIONARY FIRE - EXTINGUISHER SYSTEM. Robert L. Cooney, Atlanta, Ga.

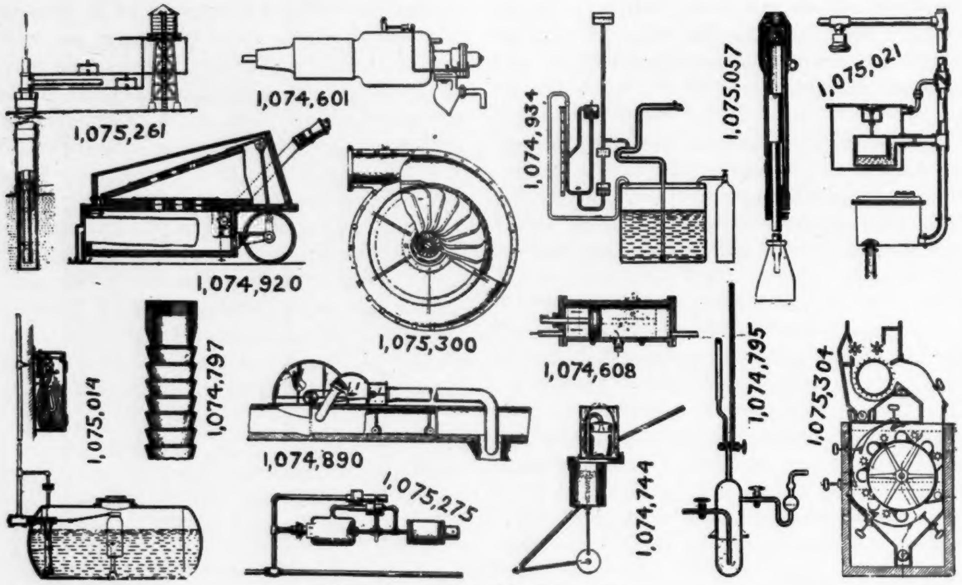
1,075,057. PNEUMATIC SAND - RAMMER. Samuel Oldham, Philadelphia, Pa.

1,075,085. WORKING WITH HYDROGEN UNDER PRESSURE. Carl Bosch and Franz Lappe, Ludwigshafen - on - the - Rhine, Germany.

In the process of working with hydrogen under increased pressure and at a raised temperature, interposing an atmosphere of nitrogen gas between the hydrogen and the hot pressure-sustaining wall of the reaction vessel.

1,075,091. STATIONARY FIRE-EXTINGUISHER SYSTEM. Robert L. Cooney, Atlanta, Ga.

1. A fire extinguisher system including means for maintaining two bodies of elastic fluid at normally balanced degrees of pressure, means for supplying a fire extinguishing agent, a supply system through which the agent flows, a valve operable whereby the degree of pressure



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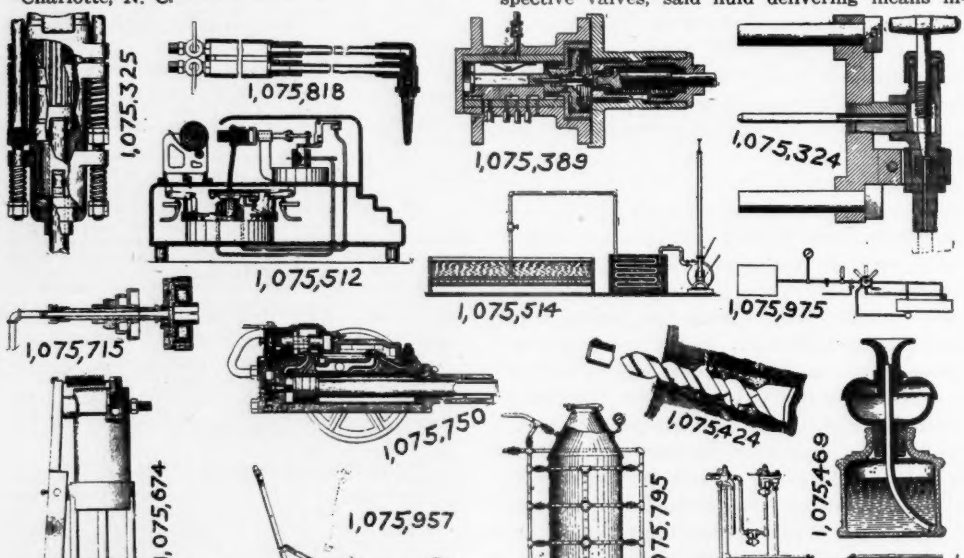
of one body may be initially reduced and means whereby the other pressure by virtue of its expansive nature becomes active upon the initial reduction of the first pressure to cause the operation of the fire extinguisher agent supply means.

1,075,197. AIR-CONDITIONING APPARATUS. STUART W. CRAMER and WILLIAM B. HODGE, Charlotte, N. C.

1,075,261. WELL-CLEANING DEVICE. JOHN FRANKLIN KILBURN, El Paso, Tex.

1. In a device of the class set forth, the combination of a working barrel, a foot valve therein, a plunger and sucker valve above the foot valve, and means to deliver fluid under high pressure into and through different parts of the working barrel and into the region of the respective valves, said fluid delivering means in-



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cluding longitudinal passageways formed in and through the wall of the working barrel and communicating with the interior thereof just above said valves and tubes tapped into the ends of said passageways.

1,075,275. LOAD-BRAKE APPARATUS. WALTER V. TURNER, Wilkinsburg, Pa.

1,075,300. CENTRIFUGAL COMPRESSOR. SANFORD A. MOSS, Lynn, Mass.

1,075,304. PNEUMATIC CLEANING DEVICE. CECIL L. SAUNDERS, Hot Springs, Ark.

OCTOBER 14.

1,075,324. VALVED CONNECTION FOR ROCK-DRILLS. SANFORD W. BROTHERS, Denver, Colo.

1,075,325. LOCKING - CHUCK FOR ROCK-DRILLS, ETC. SANFORD W. BROTHERS, Denver, Colo.

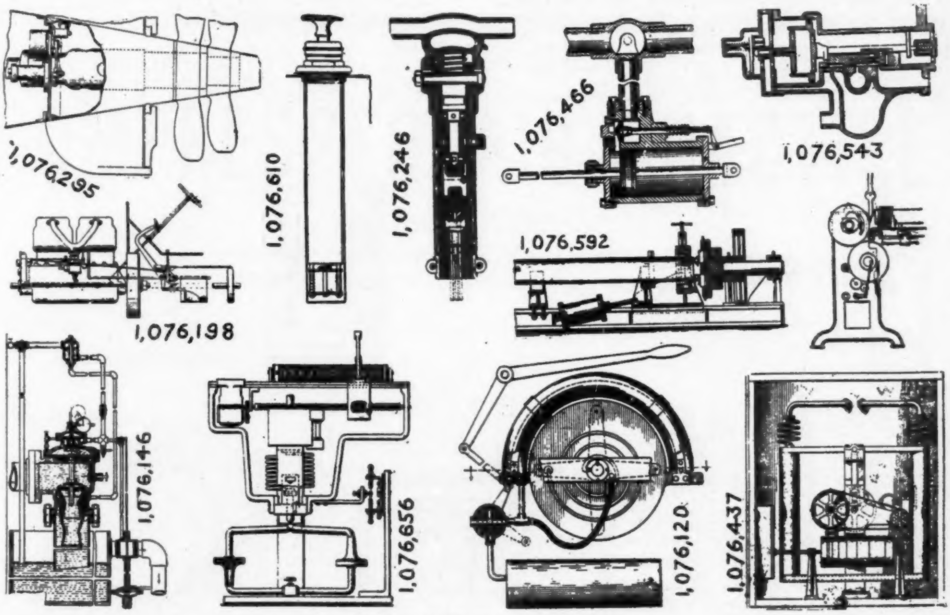
1,075,715. FLUID - ACTUATED LATHE-CHUCK. HARLAN M. LUDWICK, Parkesburg, Pa.

1,075,750. DIRECT-ACTING ENGINE. ALBERT BALL and THOMAS OFFICER, Claremont, N. H.

1,075,790. PNEUMATIC - DESPATCH - TUBE APPARATUS. ALBERT W. PEARSALL, Lowell, Mass.

1,075,795. METHOD AND APPARATUS FOR DIGESTING WOOD AND OTHER FIBROUS MATERIALS. JOHN CHARLES WILLIAM STANLEY, Santa Cruz, Cal.

1. The process herein described for the digestion of fibrous material, said process consisting in immersing the material in a disintegrating solution; admitting a heating agent into the interior of the mass and subjecting the mass to the action of the heating agent until the mass is cooked, then draining off and condensing said



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1,075,389. EMPTY AND LOAD BRAKE. WALTER V. TURNER, Edgewood, Pa.

1,075,424. ROCK-DRILL. CORWILL JACKSON, Madison, Wis.

1,075,469. PNEUMATIC ATTACHMENT FOR INK-RECEPTACLES. HENRY T. EMEIS, San Diego, Cal.

1,075,512. PNEUMATIC TYPE-WRITER. MAX SOBLIK, Dresden- Klotzsche, Germany.

1,075,514. PROCESS OF TREATING CREAM AND SIMILAR SUBSTANCES. FRANKLIN H. STANLEY, Cleveland, Ohio.

1,075,549. COMBINED AUTOMATIC AND STRAIGHT-AIR BRAKE. JOHN W. CLOUD, London, England.

1,075,674. AIR-PUMP. FRANK E. TEN EYCK, Boston, Mass.

1. In a pump of the class described, the combination with the piston operating devices adapted to be loosely mounted on an actuating shaft, a clutch for connecting said shaft and the piston operating devices, a lever for operating said clutch, an air pressure piston connected with said pump for operating the said lever by the pressure within the pump cylinder and its connections.

solution; then *admitting compressed air* into the container above said mass to thereby create a pressure upon the mass in excess of that of the heating agent and to squeeze out of the mass the remaining surplus solution.

1,075,818. BLOWPIPE AND METHOD OF USING GASES THEREIN. MELBOURNE K. DUNHAM, Boston, Mass.

1. The method of using oxygen and a combustible gas, such as acetylene, in a blow pipe which has a mixing chamber and a burner passage leading therefrom, which consists in delivering the acetylene gas directly into the mixing chamber from the rear and allowing oxygen held under a high pressure to expand into a chamber which is separate from but surrounds the mixing chamber and the acetylene gas passage leading thereto whereby the reduction of temperature caused by the expanding action of the oxygen gas counteracts, the heating effect produced by the flame on the acetylene gas being delivered to the mixing chamber so that the gases are delivered to the mixing chamber at somewhere near the same temperature.

1,075,906. SANITARY SAND-BLAST HELMET. WILLIAM DUNCAN and JOHN A. SPANGLER, Attica, Ind.

1,075,957. VACUUM - CLEANER. JOHN B. YOUNG, North Crystal Lake, Ill.
1,075,975. ENGINE-STARTER. JOHN HUME, Houston, Tex.

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1,076,057. FEEDING ATTACHMENT FOR PNEUMATIC STACKERS. JOHN W. PLUMMER, Morrill, Nebr.
1,076,069. ELECTROPNEUMATIC SWELL-PEDAL ACTION FOR PIPE-ORGANS. ERNEST M. SKINNER, Boston, Mass.
1,076,120. STARTING DEVICE FOR EXPLOSIVE-ENGINES. JOHN O. HOBBS, Chicago, Ill.

1. In a starting device for explosive engines, the combination with a starting shaft, of a crank loosely mounted upon said shaft, means for applying fluid pressure to said crank, a fluid pressure operated crank for locking said crank to said shaft, valve mechanism for controlling the application of fluid pressure to said crank and to said clutch, means for manually operating said valve mechanism to apply fluid pressure to said crank and to said clutch, and means automatically actuated by said crank for releasing fluid pressure therefrom and from said clutch.

1,076,462. PUMP FOR ELASTIC FLUIDS. KARL STEINBECKER, Charlottenburg, Germany.
1,076,466. AUTOMATIC BRAKE MECHANISM. WILBER B. THOMAS, Salem, Ohio.
1,076,491. PNEUMATIC PRESS - FEEDING MEANS. JAMES DUVALL, Camas, Wash.
1,076,543. AIR-BRAKE APPARATUS. HENRY F. BICKEL, Plainfield, N. J.
1,076,549. PNEUMATIC BRUSH. ISAAC CHAIMOVITSCH, Chicago, Ill.
1,076,592. PROCESS OF PIPE-FLANGING. JOHN H. MANNING, New York, N. Y.
1,076,610. AIR-PUMP. LINCOLN B. SHERWOOD, Indianapolis, Ind.
1,076,656. FLUID-FLOW METER. HAROLD H. MAPELSDEN, Schenectady, N. Y.

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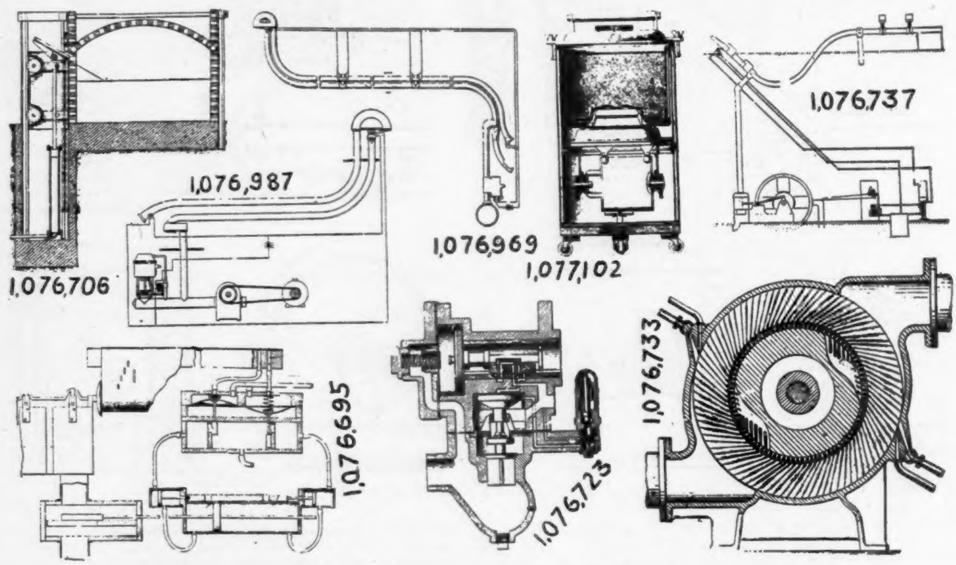
1,076,664. FLUID-PRESSURE BRAKE. JOHN W. CLOUD, London, England.
1,076,695. AUTOMATIC TEMPO-REGULATOR. PAUL B. OLSON, Chicago, Ill.
1,076,706. CHARGING APPARATUS. HARRY JOSEPH ROWE, New Kensington, Pa.
1,076,723. FLUID-PRESSURE BRAKE. WALTER V. TURNER, Edgewood, Pa.
1,076,733. TURBINE. EMIL ANDERSON, New York, N. Y.



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1,076,134. PIPE-FLANGING MACHINE. JOHN H. MANNING, New York, N. Y.
1,076,146. VACUUM-CONTROLLED DIFFERENTIAL-LIQUID-LEVEL APPARATUS. EDWARD P. NOYES, Winchester, Mass.
1,076,198. VACUUM-BRAKE. JAMES T. DICKSON, Los Angeles, Cal.
1,076,246. ROCK-DRILL. GRANT W. SMITH, Chattanooga, Tenn.
1,076,295. SINKING DEVICE FOR AUTOMOBILE TORPEDOES. FRANK M. LEAVITT, Smithtown, N. Y.

1. In an automobile torpedo, a spring-closed exhaust-valve opening from an air chamber within the shell, and means for holding said valve open when it has been opened by the escaping air to admit water to said chamber after the run to sink the torpedo.

1,076,391. ROTARY BLOWER. GEORGE L. REICHHELM, Jersey City, N. J.
1,076,437. FLUID-FLOW METER. HAROLD H. MAPELSDEN, Schenectady, N. Y.

1,076,737. PNEUMATIC - DESPATCH - TUBE SYSTEM. BIRNEY C. BATCHELLER, New York, N. Y.

1,076,969. PNEUMATIC - DESPATCH - TUBE APPARATUS. EDMOND A. FORDYCE, Boston, Mass.

1,076,987. PNEUMATIC - DESPATCH - TUBE APPARATUS. JAMES G. MACLAREN, Harrison, N. Y.

1,076,989. PNEUMATIC CONVEYER SYSTEM. WILLIAM MCCLAVE, Scranton, Pa.

1,077,034. PROCESS OF WORKING WITH HYDROGEN UNDER PRESSURE. CARL BOSCH, Ludwigshafen-on-the-Rhine, Germany.

1,077,102. VACUUM-CLEANER. JOHN W. SMITH, Chicago, Ill.

1,077,181. APPARATUS FOR USE BY PERSONS WORKING IN IRRESPIRABLE ATMOSPHERES OR UNDER WATER. ARTHUR THOMAS WINBORN, Crumlin, Wales.

GENERAL NUMBER

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DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

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Classified Buyers' Guide, Pages 12, 14, 15 and 16. Index to Advertisers, Page 8.

The Slogan of the Cameron:—"Character: The Grandest Thing."

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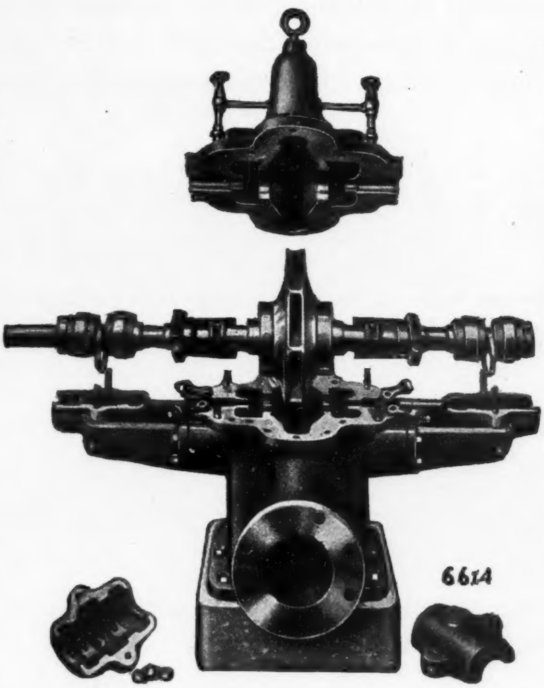

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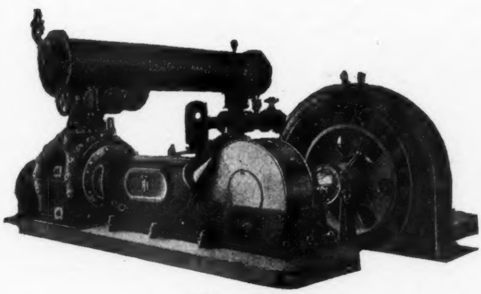

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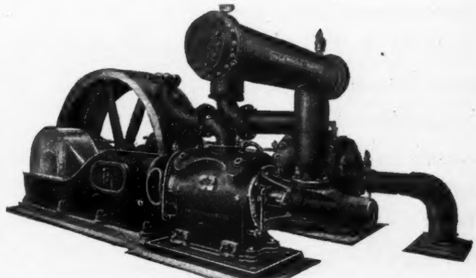

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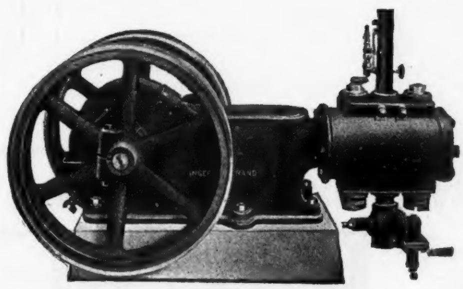

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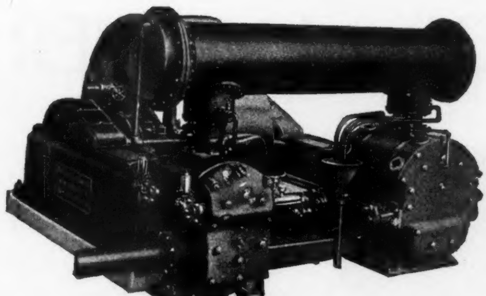

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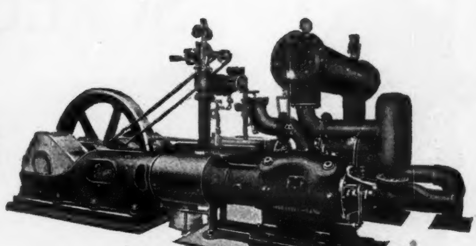

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Bury Compressor Co.
Galigher Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Pumps, Air.
Cameron Stm. Pump Wks., A. S.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Pumps, Automatic Displacement.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Pumps, Steam.
Cameron Stm. Pump Wks., A. S.
Galigher Machinery Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Quarry Machinery.
Bury Compressor Co.
Cameron Stm. Pump Wks., A. S.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
Oldham & Sons Co., Geo.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Rock Drills, Air and Steam.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Rock Drills, Electric-Air.
Galigher Machinery Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.

Sand Blast Machinery.
Ingersoll-Rand Co.

Sand Riddling Machines.
Chicago Pneumatic Tool Co.

Stone Tools, Pneumatic.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
Oldham & Sons Co., Geo.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Tools, Pneumatic.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
Oldham & Sons Co., Geo.
Stearns-Roger Mfg. Co.

Water Traps.
Bury Compressor Co.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
Sullivan Machinery Co.